Vol. 16 OCTOBER, 1922 No. 2

QUARTERLY

OF THE

National Fire Protection Association

Entered as second-class matter May 1, 1911, at the Post Office at Boston, Mass., under act of July 16th, 1894.

87 MILK STREET BOSTON, MASS.

National Fire Protection Association.

(INTERNATIONAL.)

Executive Office, 87 Milk Street, Boston, Mass., U. S. A.

OFFICERS

H. O. Lacount, *President*
Franklin H. Wentworth, *Secretary*
R. S. Moulton, *Assistant Secretary*

Rudolph P. Miller, *First Vice-President*
Dana Pierce, *Second Vice-President*
Albert T. Bell, *Chairman Executive Committee*

Members

American Institute of Architects.
American Institute of Electrical Engineers.
American Concrete Institute.
American Electric Railway Association.
American Gas Association.
American Marine Insurance Syndicates.
American Petroleum Institute.
Arkansas Fire Prevention Bureau.
Associated Factory Mutual Fire Insurance Co's. Inspection Bureau.
Associated Manufacturers of Electrical Supplies.
Associated Manufacturers of Safety Standard Films and Projectors.
Associated Metal Lath Manufacturers.
Association of Edison Illuminating Companies.
Association of the Fire Alarm Industry.
Association of Fire Underwriters of Baltimore City.
Association of Marine Underwriters of United States.
Board of Fire Underwriters of Allegheny County.
Board of Fire Underwriters of the Pacific.
Board of Fire Underwriters of the Territory of Hawaii.
Boston Board of Fire Underwriters.
British Columbia Fire Underwriters' Association.
Buffalo Association of Fire Underwriters.
Bureau of Explosives.
Canadian Automatic Sprinkler Association.
Canadian Fire Underwriters' Association.
Canadian Manufacturers' Association.
Central Actuarial Bureau.
Chicago Board of Underwriters of Chicago.
Clay Products Association.
Committee of Manufacturers on Standardization of Fittings and Valves.
Common Brick Manufacturers' Association of America.
Compressed Gas Manufacturers' Association.
Conservation and Fire Prevention Association of Indiana.
Conservation and Fire Prevention Association of Ohio.
Cotton Insurance Association.
Electric Power Club.
Electrical Supply Jobbers' Association.
Engineering Institute of Canada.
Factory Insurance Association.
Factory Mutual Laboratories.
Fire Extinguisher Exchange.
Fire Underwriters' Electrical Bureau.
Grain Insurance Association.
Gypsum Industries Association.
Hollow Building Tile Association.
Hydraulic Society.
Illinois Inspection Bureau.
Indiana Inspection Bureau.
Institute of Makers of Explosives.
Insurance Association of Providence.
International Acetylene Association.
International Association of Fire Engineers.
International Association of Fire Fighters.
Iowa Insurance Service Bureau.
Kansas Inspection Bureau.
Kentucky Actuarial Bureau.
Kentucky State Dept. of Fire Prevention and Rates.
Lightning Rod Manufacturers Association.
Louisiana Fire Prevention Bureau.
Michigan Inspection Bureau.
Millers' National Federation.
Missouri Inspection Bureau.
Mountain States Inspection Bureau.
Mutual Fire Inspection Bureau.
Mutual Fire Insurance Association.
Mutual Fire Prevention Bureau.
National Association of Building Owners and Managers.
National Association of Credit Men.
National Association of Dyers and Cleaners.
National Association of Electrical Contractors and Dealers.
National Association of Insurance Agents.
National Association of Manufacturers of Approved Hollow Metal Window Frames and Sash.
National Association of Manufacturers of United States.
National Association of the Motion Picture Industry, Inc.
National Association of Sheet Metal Contractors of United States.
National Automatic Sprinkler Association.
National Board of Fire Underwriters.
National Convention of Insurance Commissioners.
National Electric Light Association.
National Lime Association.
National Lumber Manufacturers' Association.
National Wholesale Druggists' Association.
Nebraska Inspection Bureau.
New Brunswick Board of Fire Underwriters.
New England Bureau of United Inspection.
New England Insurance Exchange.
New Hampshire Board of Underwriters.
New Jersey Schedule Rating Office.
New York Board of Fire Underwriters.
New York Fire Insurance Exchange.
Newfoundland Board of Fire Underwriters.
Nova Scotia Board of Fire Underwriters.
Ohio Inspection Bureau.
Oil Insurance Association.
Oklahoma Inspection Bureau.
Oregon Insurance Rating Bureau.
Philadelphia Fire Underwriters' Association.
Philadelphia Suburban Underwriters' Association.
Portland Cement Association.
Prepared Roofing Association.
Pyroxylin Plastics Manufacturers' Association.
Railroad Insurance Association.
Southern Cypress Manufacturers' Association.
South-Eastern Underwriters' Association.
St. Louis Fire Prevention Bureau.
Suburban Fire Insurance Exchange.
Tennessee Inspection Bureau.
Texas Inspection Bureau.
Texas State Fire Insurance Commission.
The Union.
Underwriters' Association of the District of Columbia.
Underwriters' Association of the Middle Department.
Underwriters' Association of New York State.
Underwriters' Bureau of Middle and Southern States
Underwriters' Bureau of New England.
Underwriters' Laboratories.
Underwriters' Service Association.
Washington Surveying and Rating Bureau.
Western Actuarial Bureau (Fire).
Western Canada Fire Underwriters' Association.
Western Factory Insurance Association.
Western Insurance Bureau.
Western Sprinklered Risk Association.
West Virginia Inspection Bureau.
Wisconsin Inspection Bureau.

Table of Contents.

JANE STREET WAREHOUSE FIRE, NEW YORK ..... FRONTISPIECE

EDITORIALS 105

THE INFLAMMABLE PICTURE FILM 109

A DIRT DAUBER'S NEST 111

THE NEW YORK SUBWAY FIRE 112

RADIO SIGNALING APPARATUS. *Thomas Henry Day* 115

FIRE RULES—DUPONT BUILDING 130

HAZARDS OF PORTABLE HEATING DEVICES. *Charles E. Worthington* 131

FIREPROOFING OF FABRIC. *Kling and Florentin* 134

FIRE PREVENTION INSPECTION. *Frederick H. Cowles* 141

NEW YORK CENTRAL PIER FIRE. *W. F. Steffens* 148

SOME FUNDAMENTALS OF SAFEGUARDING LIFE FROM FIRE. *C. Heller* 152

HEATING ELEVATED STEEL SPRINKLER TANKS. *C. D. Abbott* 186

Department of Fire Records.

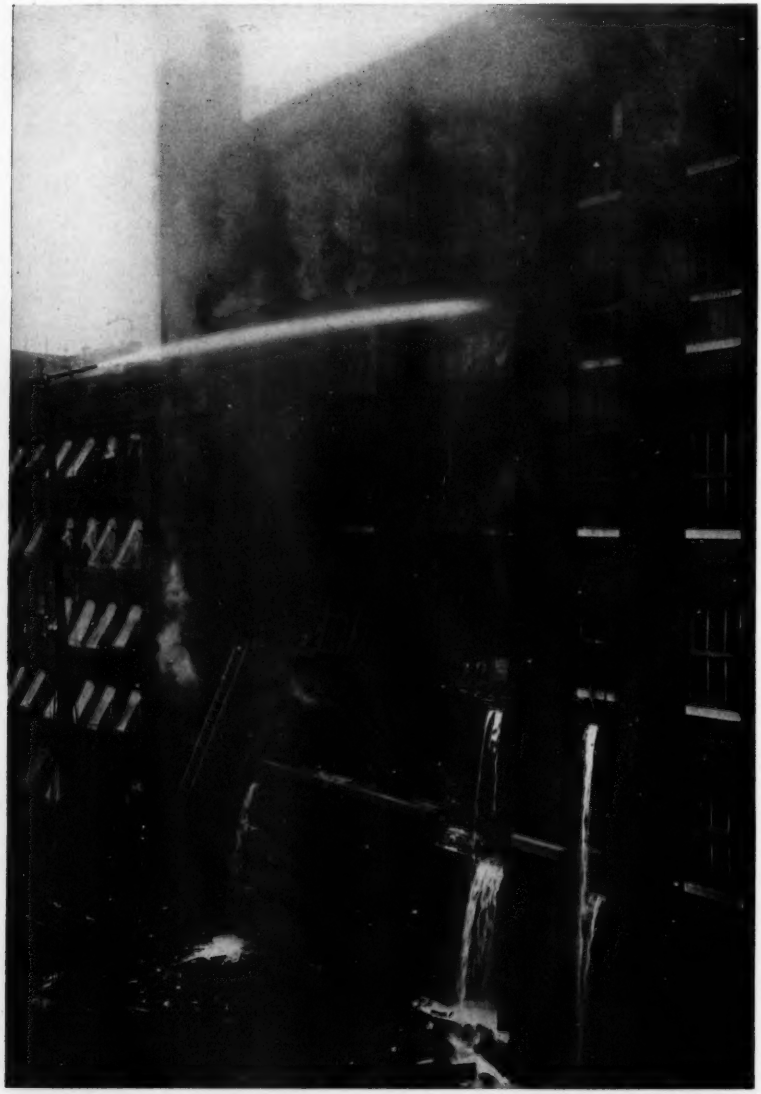
PROCESSES AND FIRE HAZARDS OF MATTRESS FACTORIES. *S. R. Robertson* 194

BALTIMORE TERMINAL FIRE. *Railroad Insurance Association* 203

SAW MILLS (Fire Record) 206

INTERESTING FIRES 211

Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.



The Jane Street Warehouse fire, New York, July 18, 1922. This was a well constructed building, but was overloaded with merchandise. Ignition and consequent explosion of magnesium powder caused the fire, which lasted for more than a week, in spite of heavy concentration of apparatus and enormous quantities of water. One fireman was killed and several were injured.

I fear you will not get very far with your "Fire Prevention Week." There have been too many "weeks," all of them for the same purpose, that of making money without paying the freight.—*American Newspaper Publishers Association, L. B. Palmer, Manager.*

The Quarterly

Vol. 16 **October, 1922** **No. 2**

The Newspapers at Their Worst. As the American people, while measuring up to the character and intelligence of the other peoples of the world in their individual capacities, occasionally do not appear to very great advantage in their official or collective expressions (such as Congress, for example), so the American newspapers, taken individually, often exhibit a knowledge of public welfare and economic fact that redeems in a sense their constant collective sublimation of the personal and trivial.

As there is a quiet spot at the heart of the cyclone at which one may not be conscious of the huge devastation that accompanies it, so amid all the uproar of Fire Prevention Week in the United States and Canada, the presidential, governor-general, gubernatorial, mayoralty proclamations, the mass meetings, Chamber of Commerce luncheons, banners, posters, show window displays and what-not, there was one spot in the World Building in New York City to which it never penetrated. This is the office of the American Newspaper Publishers Association, Mr. L. B. Palmer, manager.

On the N. F. P. A. special press list is a considerable number of individual newspapers whose editors consider the economic significance of the fire waste a matter of public interest, and whose paragraphers and cartoonists have for a number of years taken the annual recurrence of fire prevention day as the occasion for creating interesting dramatic and humorous texts and pictures. Special facts and conditions upon which such productions might be based have always been received with expressions of appreciation by the individual editors and artists referred to, whether furnished by one of our members to the paper in his home town or sent from the N. F. P. A. office direct.

Acting upon this experience we this year had the notion of extending this service through the assistance, if possible, of the publishers' association, to which we addressed the following letter:

Boston, August 14, 1922.

American Newspaper Publishers' Assn.,
63 Park Row,
New York City.
Gentlemen:

We are interested in obtaining a list of cartoon syndicates and a list of prominent newspaper writers whose material is syndicated. Could you supply us with this information? We wish to address these people with reference to Fire Prevention Week, which falls this year on October 2nd to 9th, calling their attention to

the importance of the fire-prevention movement and requesting them to issue pertinent material on the subject during that week. We will very much appreciate your co-operation in this respect.

To this letter we received a prompt reply from the manager of the publishers' association, of which the following is a copy:

AMERICAN NEWSPAPER PUBLISHERS ASSOCIATION
903-908 World Building
New York

National Fire Protection Association, August 15, 1922.
87 Milk Street,
Boston, Mass.

Dear Sirs:—

In reply to your letter of the 14th instant from which I infer it to be your purpose to secure free advertising for "Fire Prevention Week," permit me to say we are committed to the principle that those who desire to use newspapers for the purpose of reaching the public should pay the tariff provided for the space in the advertising columns rather than to seek a free ride.

In this respect, the newspapers are no different than the railroads and other transportation companies, the telephone company, the telegraph service, or messenger service. Those who wish to reach the public through those sources expect to pay the rates provided, and as the advertising columns provide practically the total revenue of the newspaper, the newspapers naturally expect propaganda or other messages for the public in the shape of advertising rather than news.

I fear you will not get very far with your "Fire Prevention Week." There have been too many "Weeks," all of them for the same purpose, that of making money without paying the freight.

If you will be good enough to read in the enclosed bulletin the paragraph headed "If It Keeps On" which is reprinted from a recent issue of *Life* I believe you will realize the truth. You may also be interested in the enclosed copy of another bulletin which we issue weekly which is designed to contain *exposés* of all such movements.

Very truly yours,
(Signed) L. B. PALMER.
Manager.

Enclosures:

The reprint from *Life* which Mr. Palmer enclosed as an aid to the interpretation of his thought was a satire upon the adoption of definite periods for propaganda. The bulletin accompanying it was his own production and recited attempts of corset makers and other similar tradesmen to impose upon the newspapers by cunningly written advertisements.

We replied to Mr. Palmer apologizing for our assumption that his association might supply us with the information desired and hazarded the suggestion that his letter perhaps expressed his personal opinion. He replied that the opinion was not an expression of his personal views alone but the views of newspaper men generally; that his association at all times cheerfully supplies information other than to its membership, but naturally only when such information is for a purpose deemed to be proper.

It is a severe imposition upon the American Newspaper Publishers Association that President Harding's Fire Prevention Day proclamation and the fire prevention appeal of the Chamber of Commerce of the United States got into some of the newspapers without paying advertising rates. Certain rebellious editors obviously saw news value and a relation to public welfare in the declaration that during 1921 more than 15,000 lives were lost and property valued at $500,000,000 was destroyed by fire; and that during the first seven months of the current year property valued at

$230,000,000 was added to the nation's ash heap. Manager L. B. Palmer, if it were left wholly to him, might impose a very profitable tax upon the dissemination of this information necessary to avert from our country its present serious physical impoverishment, for we are convinced that as official spokesman for the American Newspaper Publishers Association he must possess a value to his employers far beyond his obvious talent for writing courteous letters.

* * * * *

A Legal Notion of Fireproofing. One cannot frequent the society of our beloved and devoted vice-president, Rudolph P. Miller, without gleaning from his long and varied experience as head of the building department of Manhattan interesting sidelights on matters which seldom get into the press. The latest of these is a dictum on "fireproof" construction, laid down by the New York Court of Appeals (the highest court in the state), in the case of People vs. 131 Boerum Street Co. as reported in 238 N. Y. 268.

The defendant had questioned the authority of the fire commissioner of New York City to issue a certain order against its building, which is a factory. In the Supreme Court, the case was decided against the defendant, but on appeal to the Appellate Division, the judgment was reversed. The Court of Appeals, however, upsets the judgment of the Appellate Division, and confirms that of the trial court.

The order issued by the fire commissioner, under a provision of the Greater New York Charter, was to "provide metal or kalamein frames and sashes with wired glass for all windows . . . and make same approved self-closing."

The question seemed to hinge on an interpretation of the city ordinance which requires that "the owners and proprietors of all manufactories . . . shall . . . provide such fire hose, fire extinguishers, buckets, axes, fire hooks, fire doors, and other means of preventing and extinguishing fires as the fire commissioner may direct." The defendant contended that fire windows as ordered were not included in the things that might be required under that provision, and that the installation of such windows required structural changes, which according to a previous decision of the Court of Appeals, the fire commissioner had no authority to order.

It seems that the court of last resort, in this case, holds that the windows are not structural changes within the meaning of the decision previously rendered, and that they are of a nature similar to the things specified in the ordinance, under the rule of *ejusdem generis*. This is very interesting, and decidedly helpful to the cause of fire protection. Had the decision stopped there the high state court would have escaped the pardonable amusement at its expense accorded the fire prevention fraternity by its effort to illustrate what a simple trick "fireproofing" really is. The decision continues (the italics are ours):

> So far as the window frames or sashes are concerned, defendant could comply with the order of the fire commissioner *by painting or coating them with a certain kind of fireproof mixture*. This involves no structural change. The same is true of the requirement for wired glass in windows. A window pane is of such fragile and, therefore, temporary and changeable character, that we do not think that anybody would regard it as a part of the permanent construction of the building as would be an elevator, a chimney or a wall. The feature of making the windows

self-closing is a matter of detail involving the use of some simple device, and certainly would not involve anything more in the way of permanent construction than would the appliances which are attached to an ordinary fire door causing it to close when fire approaches.

It isn't recorded what the noise in the fire commissioner's office sounded like when, after its litigation in three courts, the No. 131 Boerum Street Company waved this opinion in its face.

* * * * *

New Haven Theatre Fire Indictments. Chief Justice Taft's recently published remarks about the need for reform in American court practice, particularly the need for prompt justice, are very pertinent to the subject of legal and criminal responsibility for preventable fire, as well as to other phases of the application of justice. As is the case with other crimes, the moral effect of convictions of those responsible for fires is largely lost as far as the general public is concerned, for by the time trial is reached, the fire disaster has faded from the public memory.

The New Haven theatre fire, November 21, 1921 (reported in the QUARTERLY, January, 1921 [Vol. 15, No. 3, p. 294]), in which ten lives were lost received widespread publicity. If the trials of manager, owner, and inspector received similar publicity, the effect on those concerned with similar theatres in other cities would be very wholesome.

A brief recital of the developments in this case since the publication of the January QUARTERLY will doubtless be of interest. Shortly after the fire, in accordance with the coroner's statements, indictments were found against the building inspector of the city of New Haven, the manager of the theatre, and the president of the theatrical corporation. The inspector was tried and acquitted. The manager, Lawrence W. Carroll, was last May found guilty of gross negligence, and fined $1000 and sentenced to one year in jail, on the common law charge of gross negligence, not on the charge of manslaughter on which he had been tried. An appeal against this decision is still pending. Alfred S. Black, president of the Connecticut Theatres Corporation, which controlled the Rialto Theatre, was found guilty of gross negligence at the same time as Carroll, the manager, but had remained out of the state and of the jurisdiction of the Connecticut authorities. Later he was indicted for manslaughter and in September was arrested in Boston. At the time the QUARTERLY went to press he had not yet been extradited to Connecticut.

The Inflammable Picture Film.

Prohibited in Paris after January 1, 1925.

We have received at the hand of the French Minister of Foreign Affairs a copy of the ordinance of April 10th, 1922, prohibiting the display of the nitro-cellulose motion picture film in Paris after January 1st, 1925. Following is the text of this ordinance:

No. 8: Second Bureau.

Prefecture of Police, Division of the Cabinet.

The French Republic. April 1922.

ORDINANCE

Concerning Motion Picture Films.

Paris, April 10, 1922.

WE, the Prefect of Police,

In accordance with the Law of August 16-24, 1790 (Title XI), that of July 19-22, 1791 (Title E, Art. 46), the Regulation of the 17th of Messidor Year VIII, of the 3rd of Brumaire Year IX, and the law of June 10, 1853;

In accordance with the ordinance of August 10, 1908;

In accordance with Art. 471, Sec. 15, Penal Code;

In accordance with the circular of the Minister of the Interior under date of March 20, 1922;

In view of the fact that the use of celluloid motion picture film presents serious danger of fire and that it is possible to substitute therefor non-flammable film;

In view of the fact that it is equitable to grant in the meantime to managements of motion picture establishments a delay sufficient to permit them to provide themselves with non-flammable films;

We order as follows:

Article One.

The use of motion picture films of celluloid or other readily inflammable material is forbidden in establishments open to the public.

Article Two.

A delay, terminating January 1, 1925, is granted to the managements of motion picture establishments in which to conform to this ordinance.

Article Three.

The ordinances of November 13, 1913, and January 26, 1916, are abrogated.

Article Four.

This ordinance shall be printed, published and posted in Paris and in the Communes under the jurisdiction of the Prefect of Police.

The General Secretary of the Prefecture of Police, the mayors of the Communes of the Department of the Seine, and the officials and agents of the police force are charged with insuring the execution of this ordinance.

For the Prefect of Police,
The General Secretary,
A. LIARD.

The Prefect of Police,
Robert LEULLIER.

Following this action by the city of Paris, the International Association of Fire Engineers, the organization of the fire chiefs of America, at their convention in San Francisco, August 17th, 1922, unanimously adopted the following resolution, and instructed their members to bring the action to the attention of the authorities of their home states.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS CONVENTION, SAN FRANCISCO, AUGUST 15-18, 1922.

Resolution on Inflammable Picture Film.

WHEREAS: The nitro-cellulose motion picture film now in general use is of the nature of gun-cotton, and the handling, transportation and storage of the same is therefore a menace to life and property, and

WHEREAS: There is now commonly manufactured in America and in Europe a film of cellulose acetate or slow-burning material rendering the same safe and non-hazardous: it is therefore hereby unanimously

RESOLVED: By the International Association of Fire Engineers that in view of the availability of a safe film the present expensive burden of inspection, regulation and surveillance of motion picture displays placed by the motion picture industry upon public fire and safety departments is unwarranted and indefensible and it is the moral duty of this industry to adopt at once in the production of all new pictures the exclusive use of the slow-burning film: and it is further

RESOLVED: That the International Association of Fire Engineers hereby calls upon the Federal, State and municipal governments to take proper steps to prohibit by law the use of the nitro-cellulose motion picture film on and after January 1, 1925.

The Pacific Coast Association of Fire Chiefs, meeting also in San Francisco, passed a similar resolution the previous week, being thus the first American body to take official action on this subject. Resolutions of the same nature were unanimously adopted by the Dominion Association of Fire Chiefs at their convention at Chatham, Ontario, on August 31, and by the Fire Marshals' Association of North America at their convention at Portland, Maine, September 13. The Fire Marshals' resolution calls upon Congress to prohibit the shipment of the nitro-cellulose film in inter-state commerce after January 1, 1925, the date mentioned in the resolutions of the other bodies.

A Dirt Dauber's Nest.

We are indebted to our member, Mr. Herbert H. Sutton, chief engineer of the Texas Inspection Bureau, for the interesting photograph reproduced above. He writes as follows:

"In some of the plants inspected in this territory, we have found it necessary to make a recommendation for the removal of dirt dauber's nests from the sprinkler heads. This species of wasp (locally designated as "dirt daubers" but called "mud daubers" in Webster's unabridged) is not common to all parts of the country.

These wasps construct mud cells and the female lays an egg in one cell and places spiders or other insects, which have been paralyzed by a sting, in the cell for food for the larva and then seals the cell up. You can note from the picture that one "crop" of insects have been hatched out (the open holes) and another family have used the old nest as a foundation for a new one.

The picture shows very clearly how much of the area of the link on the sprinkler head may be covered, and I have seen some heads where the nests totally enclosed the link."

The New York Subway Fire.

The fire in the Lexington Avenue express tunnel of the New York Subway on July 6, 1922, is of importance principally by reason of calling attention to the serious fire and panic hazards inherent in our underground rapid-transit systems. While this fire received much publicity at the time, a brief recital of the facts as reported by the investigating authorities will doubtless be of interest to QUARTERLY readers.

At 11.17 A. M. on July 6 a short circuit occurred in the panel box in the front vestibule of the fifth car of a ten car northbound express train and was first noticed after leaving the Grand Central Station. The seriousness of the arc in this case arose from the fact that in this type of subway car the main current for operating the motor is brought through a switchboard in the vestibule, whereas in other types wiring and switches carrying the main current are kept underneath the car body. (At the time of this fire there were 660 cars of this type in the New York Subway service. All of these have been rewired to have all main current conductors beneath the car body.)

Members of the train crew and passengers attacked the fire with the one quart tetrachloride extinguishers which were provided on every car of the train. It is said that six or seven of these extinguishers were used, but that they apparently had no effect on the fire, except perhaps to increase the density of the smoke. In the meantime the motorman left the train, proceeded to an emergency pull box and telephone which were located in the tunnel about 100 feet ahead of the train, and cut off the power from the third rail. This was about four minutes after the short circuit started. As soon as the power was cut off the fire was extinguished. At this time guards opened the train doors and the passengers, estimated at about one hundred and fifty, proceeded to the street by way of emergency exits. There were two of these exits used, one at 59th Street and one at 62nd Street. There was a concrete walkway on the level of the car floor and passengers proceeded along this to the exit without necessity of descending to the track level. At this point the subway is about 75 feet below the street level, necessitating the climbing of long flights of stairs to reach the street.

Of the one hundred and fifty passengers on the train, from fifty to seventy were more or less affected by excitement, smoke, gas and the exercise of climbing the 70 foot stairs. All persons on the train, except some of the trainmen, went to the street. Some of the passengers required assistance in going up the stairs and nine are reported to have lost consciousness after reaching the street. Thirty-five were sent to hospitals, but of these all but thirteen were discharged the same day. As far as is known, none of the passengers suffered any serious after effects, although a few remained in the hospitals for several days.

After the fire the gases generated by the tetrachloride extinguisher liquids were blamed for the effects on the passengers. It was said that hydrochloric acid and phosgene gases had been produced when the tetrachloride was used on the electric arc in a confined space. This seemed plausible as it was apparently in accordance with the results of investigations on the properties of carbon tetrachloride conducted by the Underwriters' Laboratories and the United States Bureau of Mines and reported in the QUARTERLY for January, 1921 (pages 221 and 237). Subsequent investigations, however, have shown that such was not the case as the subway train was not a sufficiently "confined space" to render the generation of these poisonous gases in dangerous concentrations at all likely. The cubic contents of a subway car is many times the size of the experimental spaces used in the Underwriters' Laboratories and the Bureau of Mines investigations, while the estimated quantities of extinguishing fluids used were about the same in the fire as in the experiments. This led to the inference that the gas concentration in the subway car was much less than that found in the experimental chambers. In addition to this it should be noted that the doors and windows of the car were open into the tunnel where there was good air circulation. Medical examination of the patients in the hospital showed that in no case were there symptoms attributable to carbon tetrachloride or phosgene gas poisoning. It was felt that the smoke from the burning insulation together with the excitement and exertion due to climbing the stairs was quite sufficient to account for all injuries and discomforts experienced by the passengers.

It is interesting to note in this connection that this type of subway car is constructed entirely of steel and other incombustible materials with the exception of rattan seats, wooden window sashes and the insulation of the wiring consisting of fabric impregnated with rubber, tar, and other compounds. A careful examination by the Transit Commission showed that the total weight of materials burned was 6¾ pounds not counting the paint and varnish on 140 square feet of surface the weight of which could not be readily estimated.

Shortly after the fire the subway employees were ordered not to use tetrachloride extinguishers because of fear of repetition of a similar occurrence, but this order was promptly rescinded as a result of official investigation.

It is very fortunate that there were no more serious consequences of this fire, for under slightly different conditions there might easily have been serious panic and resulting loss of life. The fire occurred shortly before noon in an up-town train upon which there were very few passengers, only one hundred and fifty on a ten car train or an average of fifteen passengers per car. If the fire had occurred during rush hours, there might have been ten times this number of passengers in each car and it is difficult to predict what might have happened. The report of the New York Transit Commission states that this fire demonstrates the adequacy of the emergency facilities provided. New York is indeed to be congratulated that these facilities were there and proved to be adequate in this case. Unfortunately all rapid-transit tunnels are not so well equipped. If, for instance, the fire had occurred in an under water tunnel,

passengers would have had to travel very much greater distances to reach the open air.

This fire has been responsible for considerable discussion about the best method of extinguishing fires in electrical apparatus in subways. Although many other methods have been suggested, the consensus of opinion, which is borne out by the recent report of the Committee on Field Practice, seems to be that at the present time the carbon tetrachloride extinguisher is the best available, although its use is open to the objection of the possibility of generation of poisonous gases when applied to fires in confined spaces. At least one subway system provides its cars with 1½ gallon soda-acid extinguishers and reports very good success with these, of course requiring that the current be cut off before using the extinguisher. If some method could be devised so that the current could be immediately cut off from any single unit in a subway train where a short circuit occurred, a considerable step forward in the solution of the problem would be achieved, for in this case the power could remain on the other cars and the train could continue to the next station. The Transit Commission, however, says that no safe device for accomplishing this has as yet been perfected.

Fortunately the operating efficiency of our underground rapid-transit systems is in most cases good, and with due diligence on the part of the operating personnel a serious subway fire disaster seems unlikely. As long as our rapid-transit systems are overcrowded during rush hours, however, the panic danger will remain.

The Metal Polish Hazard.

George H. Greenfield of the Canadian Car and Foundry Co., Montreal, Chairman of the N. F. P. A. Canadian Committee, is instructor of the Boy Scouts in Fire Prevention and examines them for the firemen's badge they are so keen to secure. "What do you know about the dangers of ordinary liquid metal polishes?" he asked four boys the other day. This was a new one and the boys stood silent and puzzled. One of them then said: "The danger is, if you polish the metal too much the rays of the sun reflecting off the bright surface may strike some combustible stuff and set it on fire."

Instructions to Ambitious Janitors.

Save your young strength. If you do your job too well you may be an incendiary.

Radio Signaling Apparatus.

By Thomas Henry Day.

New England Insurance Exchange.

(Member N. F. P. A.)

The matter of Radio Telegraph Apparatus received its first attention in the *National Electrical Code* in the 1911 issue, under the caption of Wireless Telegraph Apparatus. It continued in this form until the 1920 issue, when the subject was changed to Radio Signaling Apparatus, to include provisions for the installation and use of telephone, as well as telegraph, equipment in connection with "Radio Signaling." The hazards of both of these equipments will also be found in the instruments used in connection with the sending of pictures through the medium of Radio Signaling Apparatus.

The term Radio Signaling Apparatus may be defined as any system of signaling which successfully substitutes some medium other than wire for the connecting conductors. Many have confounded wireless telegraphy with the system invented by the Italian, Marconi, but the latter is only one form of many. The term was used to describe other systems years before Marconi's somewhat spectacular success added it to the popular vocabulary. The Science of radio signaling apparatus is attractive and is, in some degree, as hidden as the Roentgen, or X-rays, both of which are somewhat related in principle and fundamentals, and, like electricity, are not inventions but discoveries.

Historical.

In 1854, James Bowman Lindsay made calculation to demonstrate that stations in England and Scotland could, without wires, signal across the Atlantic.

In 1892, Sir William Crookes, the inventor of the Crookes' tube, when reading a paper entitled, "Some Possibilities of Electricity," said:

"Rays of light will not pierce a wall, nor, as we know only too well, a London fog; but electrical vibrations of a yard or more in wave-length will easily pierce such media, which, to them, will be transparent. Here is revealed the bewildering possibility of telegraphy without wires, posts, cables, or any of our present costly appliances."

Again, he said that Hertzian rays could be received on a properly constituted instrument, and by concerted signals messages in the Morse Code could thus pass from one operator to another.

On December 12, 1901, at 12.30 P. M., Marconi and an assistant, a Mr. Kemp, received the first transatlantic signal, which was the letter S (...), sent from Poldhu, England, and received at Cape Race, New-

Extracts from a series of papers which appeared in *The Hartford Agent* from January 1922 to August 1922 inclusive.

foundland. On October 1, 1902, trans-oceanic messages were received on the Italian warship, *Carlo Alberto,* while that vessel lay at anchor in the harbor of Sidney, Nova Scotia, the telegrams being transmitted from Poldhu, England, the estimated distance covered being twenty-three hundred miles.

Elementary Theory.

Without attempting to enter into a technical dissertation of the science, we might say that the great essential is vibration in rhythm, that is, harmonious action.

You have frequently watched the effect on the surface of the water when you have thrown a pebble into a pond, the ripples moving away from the point of disturbance in concentric circles of increasing diameters. These waves represent the combined effect of two motions of the medium through which they are propagated, a vertical and a horizontal motion, both of which decrease in strength with the increase in the distance from the center of disturbance.

If a person standing upon one side of a pool of water strikes into the water with a paddle each time in the same direction and at regular intervals, so that he maintains a rhythmical beat, it will be found that after each stroke and up to a certain maximum the waves caused by the paddle will augment in size; but if the strokes be afterward made at irregular intervals the waves will decrease in volume. Discord will tend to undo the work that has been done by rhythm. This is also true of stringed musical instruments.

Disregarding the exact nature of these oscillations, it is evident that suitable apparatus can be devised to be operated by either of the motions, and thereby indicate the occurrence of the original disturbance. Furthermore, it is evident that the greater the distance between the center of disturbance and the indicating apparatus, the greater must be the energy of disturbance, or the sensitiveness of the indicating apparatus.

At Poldhu, England, a powerful source of vibration was sending waves into the ether, and the little ripples were caught at Newfoundland by a delicate receiving apparatus which had been adjusted to vibrate at the same rate as the transmitter at Poldhu, thus maintaining the harmonious action, or rhythmical beat.

Fire Hazards.

The science of radio signaling apparatus is still in an adolescent condition. Its limit of development has not been reached, and the rules in the 1920 edition of the National Electrical Code, although adopted in March of that year, were out of date in several particulars when promulgated in December. It has been difficult to secure suggestions from those engaged in the science—their enthusiasm and technical theories, judging from personal correspondence with some of national reputation, seeming to have hidden from their consideration the possible fire hazards from such apparatus.

With the larger equipments, owned and operated by commercial interests, there has been no difficulty in safeguarding the fire hazards, such provision and caution being absolutely necessary in order that the required and expected service be efficient and reliable.

An Electrical Cobweb.

This discharge of 1,000,000 volts is beautiful and perplexing. The transmitting and converting into practical use this great volume of energy, depends entirely upon mechanical details, of which the matter of adequate insulation is perhaps the greatest.

Our chief difficulty has been with the amateur equipments, so-called, the extent of which seems to be without limit.

Before the war closed up amateur stations, there were over 8,800 transmitting stations licensed by the United States Government in the various States. During the war, some 20,000 young men were trained for radio work, and most of these are now back in civil life and either have erected or are erecting radio stations. The magnitude of the thing is therefore considerable.

Beside the possible hazards in a transmitting station, there is also a hazard in a receiving station, the hazard arising from atmospheric conditions outside of the station equipment and coming through a lightning discharge upon the antenna, or aerial, and through the collector wire into the building. In the consideration of the hazards arising through these equipments, I feel that we are face to face with a very old problem, namely, that of harmonizing scientific theories with natural laws. It has been claimed that it is impossible to break down natural laws through scientific reasoning and, in radio signaling apparatus, either telegraph or telephone, this has been found to be only too true. We fire prevention engineers can best solve and safeguard the hazards arising from these equipments by following nature's laws, even though they may appear to be in contradiction to, what seems to be, scientific theories or what we think to be scientific facts.

Under some conditions, radio signaling apparatus causes fires from a distance. This fact has been confirmed from the very interesting experiments of M. George A. Leroy, of the Municipal Laboratory, Rouen, France. His experiments were conducted along scientific lines. A description of the instruments used, although somewhat rudimentary, would be too technical for extended consideration here. M. Jacques Boyer, in a paper called "The Wireless Incendiary," which appeared, in this country, in the *Scientific American,* June 14, 1919, referred to the experiments of M. Leroy, as follows:

> The rudimentary apparatus enabled the skilled experimenter to show without doubt the incendiary action of the Hertzian waves, although their electric intensity was a minimum in comparison with the power of the large wireless stations now in service. In particular M. Leroy has set up at some distance inflammation of combustible materials such as guncotton, tinder, cotton, worsted, tow, paper, etc. For example, by his observations upon small bales of cotton enclosed in jute

wrappers with iron bands, as this material is ordinarily packed for shipment, he explains in the following fashion the mechanism of so-called spontaneous combustion which at times bursts out in warehouses or on board ships.

In the course of handling, one of the hoops which encircles the bales of raw cotton breaks or comes loose under the action of shock or some other cause, and a small fragment of the metal projects in such way as to form a miniature Hertzian resonator. Then under the influence of the wireless wave sent out from some station, sparks pass and immediately inflame the covering of the cotton in their immediate vicinity. Equally, the contact between the metal bands of the bales piled one on another in a car or packed in the hull of a boat, may establish an electric circuit offering the conditions of capacity and self-induction necessary for the production of resonance. In consequence, when the circuit finds itself interrupted by imperfect contact between two bales, incendiary sparks, apt to inflame the cotton, are likely to be produced.

When I had gained certain experience, through being called upon to investigate fires in dwellings where radio signaling apparatus was in use, the causation of such fires seeming to point to the radio signaling equipment, I communicated with a number of gentlemen who I thought, through their field of opportunity, were in a position to assist me in my research work. Among such was Mr. Joseph C. Forsyth, Chief Electrical Inspector of the New York Board of Fire Underwriters, who had had a most interesting experience, from such equipments, in a large hotel, the management of which had established radio communication between its hotels in New York City and Philadelphia. Mr. Forsyth wrote as follows:

The discharges which take place during the operation of sending radio messages over long distances cannot help but have more or less influence on any electrical conductors which may happen to lie parallel to the wave direction. This influence is almost negligible in a great majority of instances on interior installations, due to the short length of conductors exposed. This would not, however, hold good on overhead pole lines, and I fully believe that it would be found on investigation that due to the high static discharges from radio sending stations, high potentials have been induced on aerial lines which have found their way into the buildings and resulted in a break-down of insulation, followed by an arc from the normal current supply with which the building was furnished.

When radio telegraphy was first introduced on a commercial scale we had some difficulty in one or two buildings in the city (New York) which resulted in the continuous blowing of fuses on certain circuits when the radio station was in operation. An investigation was made and it was found that although these circuits were in metal conduits yet they were carried over quite some lengths directly underneath and parallel to the antenna on the roof. Before complete removal of the trouble could be effected it was necessary to change the direction of the run of these circuits; when this was done and proper grounding made on the sending apparatus, no further blowing of the fuses was noted.

In the case you have referred to, it would undoubtedly have been dangerous to life should any one have been in contact with the fixture and any grounding medium at the time of the disruption, and the presence of the insulating joint permitted the building up of the high potential on the fixture to a point where even the joint itself was disrupted.

In the closing paragraph of his letter, Mr. Forsyth makes reference to an experience which I had related to him, also to a number of other gentlemen, at a meeting of the Western New England Association of Electrical Inspectors, this being in the formal form of a report of my investigation of a fire from a radio signaling apparatus, the result of the investigation leading to the question, "Have we a new hazard, and if so, how may it be removed or guarded against?" I will quote from that report.

A Dome-like Antenna.

The Telsa Wireless Plant, on Long Island. The structure presents a curious appearance with its antenna of unique design.

Electrical Equipment.

The range and capacity of many privately owned and operated radio stations have been greatly increased since the ban prohibiting their use, a war measure, has been removed. Most of these stations are located in private dwellings which are equipped with combination gas and electric lighting fixtures, the electric lighting equipment being connected to a 110 volt, alternating current system, which system is grounded. The fixtures in the station in which this fire occurred are wired with No. 18, B. & S. gauge, copper wire, having an insulation of one thirty-second inch of rubber, and were installed with insulating joints of an *approved* make.

The sending set of the radio equipment draws its energy from the lighting system, there being the required transformer and usual "kick-back" protection without condensers. The equipment is on the third floor and the "lead" from the radio equipment to the antenna parallels some of the circuit wires of the lighting system, the "lead" to the antenna, however, being on the outside of the dwelling, which is of frame construction.

Static Discharges.

When the sending side of this station was in operation, a current of 1.6 amperes was being used. This station, in common with others, has been in operation since October 1, 1919, since which date the evidence of static discharges has been noticeable throughout the several tenements of the house, in the plumbing, fixtures, water, soil and gas pipes, also in the telephones of both of the tenements, to such a marked degree as to render them useless, because of the intense noise in the receiver when the radio equipment was in use. The circuit fuses of the lighting system have been disrupted and were, finally, increased to twenty-five ampere capacity.

"In a one-light fixture located about fifteen feet from the radio equipment, but not in the same room, the static discharges were extremely pronounced, and when the radio equipment was being operated on the morning of November 16, 1919, there was a brilliant flash which, upon examination, proved to be an arc in the canopy of the fixture, the arc igniting the insulation on the wires and melting a hole, seven-eighths of an inch in diameter, in the canopy of the fixture, which was the extent of the damage. The occupant stated that he had noticed a red discoloration on the canopy after the static discharges began.

What the Investigation Revealed

The lighting fixtures were installed about twelve years prior to the fire. A test made by me of the insulated joint, showed that the insulation between the grounded and ungrounded sides had not been impaired. An insulation breakdown had occurred on the undergrounded circuit wire of the lighting system, at the point where the wires entered the slotted opening in the sheathing tube. The sharp edge of this slot, however, showed no evidence of an arc; the lock nut, which holds the sheathing tube in position, shows a small globule of copper. The ungrounded circuit wire was in contact with the fixture at this point, which was the ungrounded side of the insulated joint, the entire fixture being at a potential opposite to that of the ground.

An arc occurred between the canopy and the insulated part of the insulating joint, melting a hole, one-half inch in depth, in the insulating compound of the grounded side of the insulating joint, the capacity of the arc being sufficient to disrupt a twenty-five ampere fuse. As the result of tests, made at the time of the investigation, with the sending set of the radio equipment in operation, it seemed that the wiring equipment of the house had an induced current impressed upon it of about 5,000 volts, in addition to the line voltage of the lighting system.

When engaged in the investigation of this fire, I learned of a privately owned and operated radio station in eastern Massachusetts, where its owner had had similar experience with the static discharges, the fixtures and fuses breaking down throughout his home whenever he used a current of two amperes on his antenna. This station, however, I was unable to visit.

All concerned have agreed that part of the difficulty which contributed to the fire was due to the overfusing of the circuit wires of the lighting system, but this is not the entire problem. This experience, which is new to me, is also new to the owner of this radio station, he being a manufacturer and an expert in the science of radio apparatus. In view of this experience, I hesitate to offer a solution at this time, but I think the problem is worthy of attention and study, at least among the following lines:

a. Would it not be wise to so re-word the rules that the use of insulating joints will not be permitted, in buildings having radio stations, on electric lighting fixtures? The wiring of such fixtures to be with conductors having a rubber insulation of at least three sixty-fourths of an inch of rubber.

b. Would it not be a good provision to provide for the installation of some device which will drain the ungrounded wire of the lighting system of the induced current, before such induced current reaches a dangerous voltage? Should such a device be possible, will it safeguard the lighting systems, of the same secondary system, in buildings relatively close to the radio station? If not, would it then appear practical to suggest that a radio station drawing its energy from a public service company be connected to an independent transformer? (Since this was suggested, many electric light companies insist upon a separate transformer for a building in which a radio signaling apparatus is being operated, thus protecting the neighboring buildings and maintaining the incandescent lamps against flickering.)

c. There appears to be another thought in this interesting problem. How much does the paralleling of the lead to the antenna, or the antenna itself, with the circuit wires of the lighting system contribute to the cause of this and similar experiences?

These suggestions and questions brought to me a much greater result than I had expected; they also brought a grave responsibility I had not even anticipated, for a gentleman in Minnesota, interested in such enterprises, wrote that he and a number of his friends were experiencing what I had described in my report, and they had been unable to solve the problem involved. He stated that he, and most of the owners of the amateur stations in the State of Minnesota, had agreed to change their radio signaling apparatus to meet any suggestion I might offer. This was gaining results in a short time, for the hazards are of the greatest concern in the amateur stations.

Another gentleman, in stating his experience, said: "I was at the

home of a friend in Baltimore, where a transmitting set was being used on the third floor of a three-story brick dwelling house. While conversing with another amateur station they were aroused by the frightened calls of the women folk, who were, at the time, in the kitchen, located in the rear of the house, on the first floor. Upon investigation, we found the lights on the first floor extinguished, and in the kitchen, a small blaze around the canopy of the lighting fixture. This fixture was a combination, gas and electric, of usual stem and casing variety, properly installed with an insulating joint. Further investigation revealed the fact that the induced current, of the order of 10,000 volts, had followed the branch circuit feeding the transformer, down the cut-outs in the pantry, on the first floor, and thence, through the cut-outs, into all of the other circuits, thus putting the electrical strain upon every bit of wiring connected with the house. The transformer referred to was the supply to the sending helix."

A more serious occurrence, also in Baltimore, was in the home of the gentleman who related it to me. Said he:

The transformer was rated at 1 K. W. when used on full power. The secondary voltage of same was rated at 20,000 volts. This was located on the first floor of a three-story and basement, brick dwelling, in a city block. Wiring was knob and tube work, divided into three circuits for lighting and a separate one for supplying the transformer. Meter was located in basement kitchen. Service entrance was in conduit and system properly grounded at meter. The circuit run from the cut-out, at meter, to the transformer primary terminals, was rather short, about twenty-five feet, one way.

Fuses in circuit supplying transformer were "jumpered," as were the fuses in the service switch. (I admit this, old man, so you can know the real conditions, but being an electrical man myself, and knowing better, it only goes to show what one will do to get a message through heavy interference, when he is striving for a distance record. Such is the fascination of radio which no one but an amateur can understand.) However, the other lighting circuits were fused with ten ampere fuses, and all O. K., except that second floor circuit was fused on one side only, the other fuse being jumpered, having been accidentally "blown" while "doctoring" the others by matchlight.

Radio ground lead was attached to water pipe at a point where the transformer was located. Distance between points of the water pipe where the ground lead was attached and where the pipe entered the ground was about ten feet. No protective apparatus was provided to carry off the static "kick-back," because I had just received the radio transformer and was giving it a test to see what it could do, in the way of distance, not waiting to install the "kick-back" preventer.

The frankness of my friend brings out the usual condition of many of the amateur stations. Many do not know the hazards involved, but a fire may result should the equipment be improperly installed. Some, like my friend, are conversant with the hazards and in their enthusiasm lose sight of them, and like a boy with a new toy, hasten on in carelessness, and a fire is the result, as we shall now see, as my friend, in his frankness, tells us more of his experience.

I had been working the transmitter on comparatively low power and decided to test out my sending radius with the new transformer open to the limit. I started my rotary spark-gap and gradually increased the input of the transformer primary until about eleven amperes were flowing in the circuit. I had occasion to start and stop the rotary gap motor several times to adjust the electrodes, and in doing so I noticed that after the double-pole knife-switch, that was used for this purpose, was opened, and before the rotor had come to rest, *streamers of sparks jumped from each switch blade to its respective switch jaw for a distance of fully*

Photo, courtesy Mr. Hiram Percy Maxim, Hartford, Conn.

One Home Apparatus That is Well Installed.

The radio signaling apparatus in the home of Mr. Hiram Percy Maxim, Hartford, Conn. Mr. Maxim is president of the American Radio Relay League. Most amateur experimenters locate their station in their home, and inasmuch as they are unable to change the surroundings they must, to a certain extent at least, take things as they are. A careful study of the conditions will, however, often enable one to overcome any seeming handicap which may exist. This is just what Mr. Maxim has done. As a result, he has an efficient equipment without some of the unfortunate hazards which surround other amateur stations. Mr. Maxim made frequent grounds inside and outside of his home. He made at least twenty driven pipe grounds, running the ground conductor from the pipes to a water pipe outside of the foundation wall. Inside of the house, Mr. Maxim connected, electrically, all soil, gas, heating and other metal conductors by means of a copper bonding wire, and connected this bonding wire to a water pipe, thus providing means for the "draining" of any static accumulation within his home.

one-half inch, or more, indicating that the static "kick-back" was about 10,000 volts or above, and this high voltage was flowing into the circuit supplying the transformer and rotary-gap motor.

I proceeded to operate the transformer at full power for some minutes, when I noticed the rotary-gap motor slowing down and smoke coming from its windings. As I was investigating this trouble, I heard a loud crashing in the room directly above the one in which the apparatus was located. I investigated immediately, and found that the cord of a small portable lamp, which was placed upon a table so that the flexible cord crossed a gas pipe in its path to the receptacle, had been burnt in two and the end that was attached to the plug was dangling beside the gas pipe. An arc was playing from the end of the cord to the gas pipe, and the heat of this, together with the flame from the burning insulation, had ignited the dry wood of the baseboard, which was also burning.

After opening the main service switch, I made an examination of the rest of the house to determine if further damage had been done. I found in the room next to the operating room, on the first floor, the tape insulation of the fixture connections had been punctured and a small arc started in the outlet box. Thus you will realize that the "kick-back" broke down the insulation of the electrical system in three different places at the same time—one in the motor windings, one in the portable cord, and one in the fixture.

Of course, had the main switch and the circuit supplying the portable lamp been properly fused, the arc from the cord to the gas pipe would not have been so intense. Several inches of the cord were consumed and the meter was burned out, besides.

My questions brought to me a great many similar experiences, which, if related here, would only be cumulative evidence of the hazards I have endeavored to emphasize. Mr. A. T. Sampson, of Lynn, Mass., an electrical engineer of thirty-five years' experience, advanced his opinion in the following technical manner:

In my mind, there can be no question but that the principal burning was done by the low-pressure current of the lighting service. And it is evident that high-pressure was on these wires and was not led off by the low ohmic resistance path to ground, namely, through the large secondary net-work with one side grounded and the other substantially so; through whatever lamps may have been burning, the potential loops of the many meters, and, finally, through the secondary of the transformer. These conditions would make it impossible to build any high pressure on these secondary wires, except there be sufficient inductive resistance to prevent the flowing to ground over these low ohmic courses.

In view of the fact that this pressure did exist, its breakdown very near to the source of inductive energy means that grounding by drainage coils, or otherwise, would not be effective, in my opinion. From observation of the fixture, and from description of the high-potential discharges, the sparks are of sufficient intensity to carbonize the insulation over the short gaps, in which they were breaking through, and finally carbonizing sufficient to start a current flow which gradually grows larger, until the relatively low-resistance flame, or arc, builds up the volume to an injurious point.

I have felt for a long time that definite steps should be taken to limit the size of fuses that can be used on lighting circuits. The largest number of points where we desire to limit the fusing capacity of wires, is on the branch circuit end, and if ten amperes is recognized as a safe limit for this, then all cut-outs used for this purpose should not be permissible of a larger fuse being used.

In commenting upon my report of a fire from a radio signaling apparatus, Dr. Elihu Thompson, of the General Electric Co., Lynn, Mass., under date of January 23, 1920, wrote, in his usually lucid manner, of his early experiments in high frequency currents. The interesting account of his experiences follows:

I do not think there is any need of surprise as to the happening which you mention. We know that the induction effects of high frequency currents are very apt to give rise to high voltages, especially if a portion of the wire system has an oscillation period which corresponds to that of the antenna system.

Away back in 1875, my early experiments taught me that it was possible to get sparks hundreds of feet away from a system of very moderate extent operating as do the wireless systems of today. I obtained results which, in fact, would indicate the existence of statically induced charges in metal bodies of thousands of volts; and, of course, on account of these early experiments I have been ready to expect the possibility of similar effects even on a larger scale being produced by the high power wireless outfits.

Of course, the main trouble as to the burning in this case was due to the extra heavy fuses which were put in for the purpose of avoiding the constant "blowing" of fuses. In this case the remedy was practically worse than the disease, because, when a short circuit did occur, there was bound to be fusion and a strong arc. If a radio station of considerable power is to be operated anywhere near a lighting or power system, it will be necessary to increase to a large extent the insulation of the whole to prevent just such happenings.

Extent of the Hazards.

Unless we succeed in our efforts to educate the users of radio sig-

naling systems, more especially the amateur owned equipments, that the hazards arising from such apparatus may be lessened by the observance of some simple installation details, the opportunity for difficulty, both through fire and personal accident, will increase because of the wide application of this interesting branch of the science of applied electricity.

Early in February of this year, I enquired of a manufacturer as to the extent of these equipments, and he replied, "There are now over 500,000 amateur stations in this country and the end is not yet in sight. I predict that we shall have over 1,000,000 before the close of the present year. It is now impossible for manufacturers to meet the demand; we are only filling four-tenths of our daily orders, notwithstanding the fact that we have greatly increased our manufacturing space and equipment."

The manufacturers, also the owners of the radio equipments, admit that there is a hazard and are urging the use of a warning sign that the personal accident, at least, may be safeguarded against.

The more I have studied and experimented, the more I have become convinced that by (a) the removal of all parallelism with the station equipment and the power and lighting circuits, and with the ground conductor for the protective devices and the operating ground conductor of the station equipment, (b) by the reduction, in length, of the operating ground to the shortest possible minimum, (c) by the selection for the proper location for the protective devices, the proper grounding of the metal conduits, armored cables and metal raceways, as the case may be, and (d) by the selection and maintenance of a permanent and an efficient path to ground for the protective lightning ground, operating ground, ground of the protective devices and conduit, armored cable and metal raceways, there will be found the safeguard of the station equipment against fire resulting from the use of such equipment and installation.

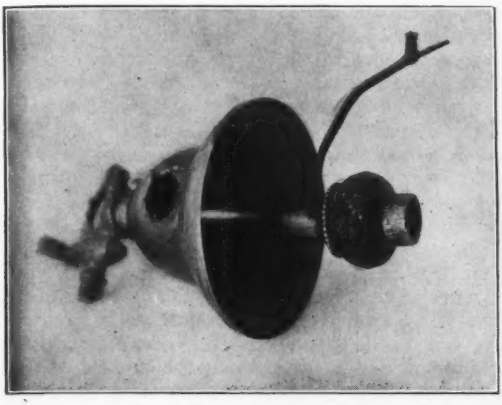
As to the protection from the personal accident hazards (more especially in a station having a transmitting equipment), the antenna lead-in and the operating ground conductor must be installed so as to have a five-inch air-gap creepage distance between them and extraneous surfaces.

In order that a station and its equipment, as well as the building in which it is located, may be reasonably protected against fire and personal accident hazards which may arise through such equipment, the following details should receive attention and consideration.

The Antenna.

The first and most important part of a radio equipment is the antenna. The ideal station will have an outdoor antenna constructed and installed in a strong and durable manner well above buildings and away from metal stacks, transmission lines and trolley feeders. In selecting the location for the erection of the antenna, attention should be given to the proximity of electric light and power lines, that the antenna span wires will not be strung over or under lines having a potential of over 600 volts; nor should the span wires be over or under grounded trolley lines or trolley feeders.

It may be necessary, however, because of local conditions, to erect the antenna so that the span wires will be over, or, possibly, under the ordinary electric light or power wires of 110 volt or 220 volt systems. In



How One Fire Started.

This combination fixture was located about fifteen feet from a radio equipment but not in the same room. When the radio equipment was being operated there was a brilliant flash which proved to be an "arc" in the canopy of the fixture. The "arc" ignited the insulation on the wires and melted a hole 7/8 of an inch in diameter in the canopy.

The writer investigated this fire soon after it occurred and found the electric lighting circuits to be greatly overfused. In his efforts to "get through" when there was considerable interference, the operator had erupted the fuses a number of times and finally installed 25 ampere fuses where nothing larger than 10 ampere fuses should have been installed. The sending equipment had been giving trouble for some time. There was a repeated blowing of fuses and static discharges were noticeable throughout the several tenements of the house in the plumbing fixtures, lighting fixtures, water, soil and gas pipes. The telephones of both of the tenants were also affected, the latter to such a marked degree as to render them useless because of intense noise in the receiver when the sending equipment was in use.

As the result of tests made by the writer soon after the fire, with the sending equipment in operation, it was found that the electric light system of the house had an inducted current impressed upon it of about 12,000 volts in addition to the normal line voltage. It was further found that the ground wire, as well as the "lead in" wire from the antenna, was in parallel with some of the circuits of the electric lighting system.

this event, the construction should be of such a character that, in the event of failure of either the antenna or the light and power wires, or both, one or both will not fall upon the other or come in contact with each other through swinging or sagging. The antenna should be located and installed in such a manner that the lead-in wire will be free and clear from all parts of the building and other extraneous matter.

Splices and joints in the antenna span, unless made with approved clamps or splicing devices, should be soldered. The reason for these suggestions will be obvious to all interested, and they should receive attention for both receiving and transmitting equipments having outdoor antenna.

Lead-in-Wire.

The hazards of a receiving equipment are somewhat limited, being largely of the atmosphere, and in this respect do not differ greatly from those of the public telephone systems with their pole lines radiating in all directions.

The lead-in wires should be of copper, approved copper-clad steel, or other metal which will not corrode excessively, and in no case should they be smaller than No. 14 B. & S. gage. Some are advocating, for use in receiving equipments, No. 17 B. & S. gage copper-clad steel, the steel center being equal in strength to the copper wire of a larger size. Lead-in wires on the outside of buildings should not come nearer than four inches to electric light and power wires unless separated therefrom by a continuous and firmly fixed non-conductor that will maintain permanent

separation. The non-conductor should be in addition to any insulation on the wire. Lead-in wires, in all instances, should enter the building through a non-combustible, non-absorptive insulating bushing.

The above suggestions apply to receiving equipment only. For transmitting equipments there is a need for provision for safety against possibilities other than those to be found in the atmosphere. The further removed the antenna, lead-in wires, and all parts of the wiring of the station are from parallel conductors of any kind, the less will be the danger of induced currents. None of the station equipment, either indoors or out-of-doors, should be permitted to parallel any electric light or power wires, but should run at right angles to such conductors.

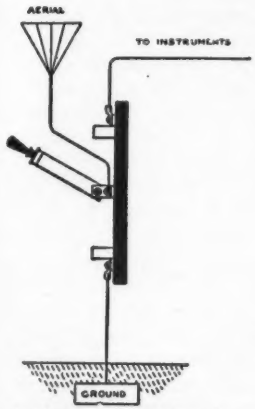
The nature of the metal to be used for the lead-in wires for a transmitting equipment should correspond to the suggestions for the lead-in wires for receiving equipments. The antenna and counterpoise conductors and wires leading therefrom to the ground switch, where attached to buildings, must be firmly mounted, five inches clear of the surface of the building, on non-absorptive insulating supports such as treated wood pins or brackets equipped with insulators having not less than five-inch creepage and air-gap distance to inflammable or conducting material. Where desired, approved suspension type insulators may be used.

In passing the antenna or counterpoise lead-in wires into a building, a tube or bushing of non-absorptive insulating material should be used and should be installed so as to have a creepage and air-gap distance of at least five inches to any extraneous body. Should porcelain or other fragile material be used, it should be so installed as to be protected from mechanical injury. A drilled window pane may be used in place of a bushing, provided five-inch creepage and air-gap distance be maintained.

Protection Against Lightning.

The methods for protecting station building and station equipment from lightning discharges vary, in detail, as to the nature of the equipment, those for receiving equipments being met with an approved lightning arrester which will operate at a potential of five hundred volts or less. The lightning arrester should be properly connected and located, inside or outside of the building, as near as practicable to the point where the lead-in wires enter the building. The lightning arrester should not be placed in the immediate vicinity of easily ignited stuff, or where exposed to inflammable gases or dust or flyings of combustible materials. A grounding switch may be installed in addition to but not in place of the above suggested lightning arrester. It has been found, through field experience, that the average amateur does not recognize the importance of changing his grounding switch to the ground side, when the station is unattended. The installation of a lightning arrester for a receiving equipment thus becomes an imperative part of the equipment.

For the purpose of protecting a transmitting equipment, a lightning arrester is not practicable, and a number of radio engineers, including the writer, at a conference in New York, last March, recommended the installation of a double-throw knife switch, the specifications and design of which correspond to the standard sixty ampere, six hundred volt switch classifications, with the single exception that the use of slate bases are not recommended.



A diagram showing how the lightning switch should be arranged and connected.

This switch should be so located, either inside or outside of the building, that its current-carrying parts will be at least five inches clear of all parts of the building or other conductors, and it is to be employed, when the station is unattended, to connect the antenna and counterpoise lead-in wires to the protective ground conductor.

Protective Ground Conductor.

Antenna conductors of both receiving and transmitting stations, also the conductors of counterpoise, when such are used, must be effectively and permanently grounded at all times when the station is not in actual operation (unattended) by a conductor at least as large as the lead-in wire. The ground conductor should be run in as straight a line as possible to a good permanent ground, preference being given to water piping. *Under no circumstances should gas piping be employed as a medium to ground.* Where water pipes are not available, the following methods may be employed: grounded steel frames of buildings and other grounded metal work in buildings, driven pipes, buried plates, cones, etc.

The protective ground wire should be protected against mechanical injury, and where the ground wire is connected to pipes, the connection should be made through the medium of an approved ground clamp, the ground wire being soldered into the terminal of the clamp. In the installation of the protective ground wire, it is not essential that it be insulated or even mounted on insulating supports.

Operating or Working Ground.

A good operating or working ground is imperative where a counterpoise is not employed. In many instances this may be best obtained by securing the ground wire to the water piping or to the pipes of a heating system (hot water or steam) by means of an approved ground clamp. If these methods are not available, then resort to either driven pipes, buried plates or cones, or attach the ground wire to the grounded steel frame of a building or to other grounded metal work. Gas piping, however, should never be employed.

The shorter the operating or working ground the better it will be for the station equipment. Many radio engineers urge that the instruments be located within five feet from the ground connection. This is especially true of transmitting equipments. I have secured the best results, from the standpoint of parallelism and subsequent elimination of fire hazards, when the instruments have been but eighteen inches from the initial ground connection.

While the size of the ground conductor for a receiving equipment should not be smaller than No. 14 B. & S. gage, the operating or working ground conductor for a transmitting equipment should be a copper strip not less than three-eighths inch wide by one-sixty-fourth inch thick, or of

copper or approved copper clad steel having a periphery or girth (around the outside) of at least three-quarters inch (for example, a No. 2 B. & S. gage wire), and should be firmly secured in place its entire length. This operating or working ground conductor should be protected and supported, in regard to its creepage and air-gap distance, for a transmitting equipment, similar to the suggestions offered for the installation of the lead-in conductors of a receiving equipment. As an extra precaution, where this ground conductor is within reach, it should be guarded against accidental contact on the part of some one in the station.

Energy from Public Lighting Company.

Sometimes it is desirable to take the station energy from the lines of the public electric lighting company. This is especially true with a transmitting equipment. The use of a transformer connected to the mains in the street, which will supply the station alone, will greatly lessen the opportunity for some hazards. As an additional safeguard the several circuits should be installed in approved metal conduits, armored cables or metal raceways. Should lead-sheathed wires be used, they should be further protected throughout their entire length by approved metal conduit or metal raceways. These metal protective systems should be adequately and permanently grounded.

High Potential Surges and Kick-backs.

With transmitting equipments there is the possibility of surges and kick-backs which may cause serious trouble on the lighting circuits, especially when the station equipment is connected to the street or public supply. That such circuits may be protected from surges and kick-backs, there should be installed in the supply line to the station equipment, as near as possible (the closer the better) to each radio transformer, rotary spark-gap, motor-generator set and other auxiliary apparatus, one of the following protective devices:

1. A shunting fixed spark-gap of not more than one-thirty-second inch separation in conjunction with two condensers (each not less than one-half microfarad capacity and capable of withstanding 600 volt test) in series across the line and with the mid-point grounded.
2. Two vacuum tube type protectors in series across the line, with the mid-point grounded.
3. Non-inductively wound resistors connected in series across the line, with the mid-point grounded.
4. Two carbon filament lamps connected in series across the line, with the mid-point grounded.
5. Electrolytic lightning arresters.

Great care should be exercised that the ground wire of the surge and kick-back protector devices does not run in parallel with the opening or working ground wire when within a distance of thirty feet. The ground wire of these surge and kick-back protective devices must not be connected to the operating ground or to the operating ground wire.

Wires Inside of Buildings.

Faulty installation of electrical apparatus is a prolific cause in the creation of hazards. In most instances the faulty installation is due to the inexperience of the owner of the station equipment.

In many of the amateur stations I have inspected, I have found that the circuits supplying current for the high voltage transformer of the

experimental radio transmitter have been given little or no attention. The wiring is frequently installed in a slipshod manner, very often from a miscellaneous assortment of material unsuited for the purpose. Improper insulation of conductors from each other and from surrounding objects, insufficient carrying capacity of conductors, absence of proper protective devices and the overloading of circuits are the chief shortcomings. The service rendered by such poor construction is usually very unsatisfactory, and, according to Mr. J. Andrew White, in Practical Amateur Wireless Stations, "causes excessive drop in voltage at the transformer terminals, blinking of lights and other annoyances, not to mention the fire hazards sometimes incurred."

In addition to the rules in the National Electrical Code, it would be well to observe the following:

Wires inside of buildings should be securely fastened in a workmanlike manner and should not come nearer than two inches to any electric light or power wire unless separated therefrom by some continuous and firmly fixed non-conductor making a permanent separation. This non-conductor should be in addition to any regular insulation on the wire. Porcelain tubing or approved flexible tubing may be used for encasing wires to comply with this suggestion.

Protective Fuses.

A fuse is an "electrical safety valve," in that it serves to protect a circuit from an undue overload. With very few exceptions the circuit from the public supply to a radio equipment should never have larger than ten ampere fuses. *Should the fuses "blow," the cause should be removed—the size of the fuses should not be increased.*

The object of the fuse is to protect circuits from overloading—which means overheating. Its general employment has attached a sense of security to the use of electric service. When a fuse is improperly replaced, this protection is removed, without, perhaps, the knowledge of those using radio equipments connected to the circuit. Reliance may still be placed upon the automatic prevention of the delivery of too much power for safety, but the sense of security has now become a false one. Through carelessness, ignorance or accident, a dangerous amount of power may be concentrated at a point where it cannot be controlled, with resultant injury to persons or property, or to both.

Overfusing a circuit is exactly analogous to setting the safety valve of a steam boiler for a higher pressure; and replacing the fuse with copper wire, pennies or other illicit methods is analogous to tying the valve down. In both cases the protection which is depended upon to prevent disaster is removed. Such practice is indefensible. One might expect to find it confined to the ignorant, the mischievous or, perhaps, the criminal. But this is not the case. It is usually those who are familiar with matters electrical who are responsible for instances of this kind. They find the protection works inconvenience at times, so they do away with it altogether, especially when they are endeavoring to "get through," and take a chance that something disastrous will not happen. The chance is usually a small one, and after several chances have been taken without a serious result, the growth of a habit has been started. The seriousness of the resulting condition is realized only by those who come in contact with the resulting disasters.

ORANGE STREET
FIRE RULES
DU PONT BUILDING
This plan has been prepared to show building exits, so that should emergency arise you will know their location.
Locate your room on this plan—note the exits, particularly the nearest exit, and remember where it is.
Should fire occur, don't become excited—leave building quickly and quietly.
Don't throw matches, pipe ashes or lighted cigars or cigarettes in waste paper basket, out of windows or leave them on your desk.
Don't keep explosives, powder or other dangerous material in your office.
Report at once to the Building Superintendent any fire, or condition which may cause fire.
The location of fire extinguishing equipment is shown thus,
To discharge chemical extinguishers turn bottom up.
Do not attempt to use fire hose unless at least two men are holding nozzle.
DU PONT BUILDING CORPORATION
Incorporated
TENTH STREET
ELEVENTH STREET
FIRE ESCAPE
EXIT
LIGHT WELL
LIGHT WELL
HOTEL
MARKET STREET

The typical floor plan shown above is printed on the back of the telephone directory of the du Pont Company. This is an excellent method of calling the attention of employees to the fire rules and exit facilities of large plants and is worthy of general adoption.

Courtesy of H. L. Miner (Member N. F. P. A.)

Hazards of Portable Heating Devices.

By Charles E. Worthington.
(Member N. F. P. A.)

The present fuel shortage is quite certain, by promoting the use of substitute methods of heating, to effect some increase in existing fire hazards and introduce some new ones. A considerable hazard is likely to result from the inexpert conversion of apparatus designed to supply supplementary or emergency heat to the purposes of primary and continuous heating.

Portable apparatus is not in general well fitted for continuous heating, since there is usually no provision for disposing of the products of combustion which are injurious to health and at times may produce fatal results.

When apparatus of this nature is operated in poorly ventilated spaces the oxygen in the air is reduced to a point where it will not fully sustain either life or fire. As necessary oxygen is depleted life and combustion slacken and eventually die; a rather simple process in the living creature but somewhat more complicated in the case of fire. The principal product of complete combustion is carbon dioxide. As the supply of oxygen diminishes and combustion slows down the amount of oxygen is insufficient to convert all of the consumed carbon to carbon dioxide, and carbon monoxide (a compound of carbon and less oxygen) appears in increasing volume. Not only is this gas extremely poisonous but it retains the capacity for absorbing additional oxygen quickly, or, in other words, it is explosive and aided by unconsumed carbon in the form of smoke may explode with considerable violence. Carbon monoxide is produced by almost all incomplete combustion.

Users should be forcefully warned that under no condition should apparatus of this kind be used unless a door is at least partly open, and preferably also a window. The open door is important because as the gases resulting from combustion are heavier than air and fall to the floor, the ventilation must extend to the floor level. This can be best visualized by imagining the invisible gas to be water. It will be easily realized that the water would flow out of a partly open door whereas were the door closed and only a window open it would have to become deep enough to overflow the window sill and the water below that level would remain. It is easy to see that children on the floor and small animals might be seriously affected without any knowledge of people in chairs or moving about. If, however, the house is normally heated by a hot air furnace with floor registers and these are kept open, they will answer the purposes of ventilation admirably provided the cold air box is not closed.

The products of combustion of oil and gas are all heavier than air and fall to the floor. If not removed by proper ventilation they tend to

form a layer above the floor and prevent the warm air above from coming down, thus making for cold floors. Proper ventilation is not merely safety but economy.

In general, portable heating devices become very hot if used continuously for any considerable period and consequently must be kept at a good distance from woodwork or combustible material. They vary greatly in this respect and some concentrate heat at special points.

Kerosene Oil Heaters.

Kerosene oil heaters are strictly portable apparatus and are all of one general type, in effect being large lamps, usually having center draft with tubular wick, and sheet iron tops that do duty both as chimneys and radiating devices. Certain structural features are common to all of these. The wick is encased and moves in a metal tube and is raised or lowered by a serrated wheel which must reach the wick through an opening in the tube. Air for combustion is drawn up through a plate of perforated metal and made to converge on the wick just above the tube by a cap or dome. The heat of the flame produces the draft.

Kerosene itself is not explosive but when heated above 100° F. gives off vapors which are explosive when mixed with air. Should the oil in the font be heated vaporization at once sets up internal pressure sufficient to completely expel any air in the font, unless the oil is very low, so in fact before the vapor can explode it must escape. Explosions of oil heaters except as a result of long continued exposure to external fire rarely if ever occur, but sufficient long continued heat will explode the font by mere pressure, exactly as it would if it contained water, and distribute explosive vapor and burning oil.

In cases of so-called explosions, usually what really happens is a flare. This is the inevitable result if the wick becomes ignited at the slot or perforation where the wheel operates and often occurs when the wick is turned too high in the endeavor to compensate for insufficient air supply. This flare produces some dull flame, much smoke and considerable heat. It prevents, by expanding the metal parts, any operation of the wheel that moves the wick and pretty well wrecks the heater. Usually the oil will burn out if left undisturbed but it is quite certain to produce heat in the process that will ignite any nearby combustible material and give off an immense volume of dense oily smoke. A continued flare may, but does not necessarily, terminate in an explosion. More often the thread of the cap or plug at the filling hole strips and gives a vent, in which case oil will spurt out.

As the heat of the flame is what produces draft and bad adjustment of the wick produces flare, the wick usually requires several adjustments after lighting. The perforated plate through which the air is drawn must be perfectly clean with perforations not clogged. The air supply must not be impaired.

In all patterns of kerosene oil heaters there are rings about the base of the burner which are deeply grooved; these catch all seepage and char. At 100° F. (only 25° above the ordinary heat of a room) oil or oil char gives off combustible vapor which the draft is likely to carry up to the flame, whence it flashes back and ignites the oil or char in the groove, whereupon trouble and usually a flare ensues.

To operate a kerosene heater with reasonable safety observe these rules:

1. Keep the perforated plate and all grooves or other places where oil and char can accumulate perfectly clean—cleaning thoroughly daily. This is a most important matter and one that is also generally neglected.
2. Keep font well filled.
3. See that the heater is continuously attended for at least 30 minutes after lighting, and that it is not left unattended for any considerable period after the first half hour.
4. Keep the heater at least two feet away from woodwork, beds or anything combustible.
5. Keep the heater out of strong drafts.

If the heater smokes and wick raising device refuses to operate and there is any flame except at top of wick tube where it should be, carry the heater outside and let it alone. Unless the flare has made great progress this can be done by hand or using a stick for lifting.

Be sure in moving the heater about under normal conditions that the top is securely latched down to the base.

Kerosene oil heaters are unfit to be lighted and left unattended over night. The hazard of doing this is extreme. This heater is the least adapted to heating for any continued period of any form of portable device.

Gas Heaters.

These readily fall into four types (not considering permanent equipment) of varying construction and hazard.

1. GAS-STEAM RADIATORS. These are cast iron radiators with a steam generating device in base heated by complete combustion burner. Usually the products of combustion are discharged into the room. These radiators do not become hotter than steam radiators and if properly connected to the gas supply are not particularly hazardous.
2. RADIANT. These use iron radiating elements heated by complete combustion burners encased in a perforated metal hood. As a rule these are provided with proper vents for chimney construction. They should be placed at safe distances from woodwork.
3. RADIANT. These use as a radiating device an exposed sheet of radiating material, usually asbestos in some form. Complete combustion burners are used to heat the sheet. The only special hazard of this type of heater is that the radiating sheet gets very hot and should be screened to prevent clothing, etc., coming in contact with it.
4. RADIANT. These have a polished metal reflector and open flame burner. The burner is usually well protected.
5. STOVE TYPE. These have open flame burners in sheet iron cylinders or in tubular sheet metal radiators. No special hazards are involved if the heaters are kept well away from combustible materials and care be taken to see that *all* jets (there are usually several) are lighted.

The principal hazard of gas apparatus lies at the point of supply, which is as a rule rubber tubing. Iron pipe should invariably be used where practicable, but if not, tubing of the "armored" sort. If tubing is used it should be examined frequently and at the first indication of stiffness or brittleness replaced.

One rule should be carefully observed, that is, never turn off gas at the valve on the heater (if there be such) but always at the point of connection to supply.

Electric Heaters.

There is very little to be said about this class provided the wiring is sufficient. There is some danger in making connection to the socket designed for a lighting bulb which requires a current much less than that needed for a heater. Where any considerable use of these devices is contemplated, it is better to have a special heater circuit with receptacles at proper points.

Fireproofing of Fabric.

With Special Reference to Theatre Decorations.

By André Kling and Daniel Florentin, of the Paris Municipal Laboratory.

The precautions necessary to reduce danger of fire in crowded places have long been studied by the technical service of the Police Department, and various regulations, modified as building construction improved, have been worked out on this subject since 1830.

With a view to clearing the situation in regard to the fireproofing of theatrical material, the Prefect of Police on December 15, 1913, appointed a commission to give advice regarding the enforcement of regulations concerning the fireproofing of scenery and properties in theatres.

The problem of fireproofing scenery and properties, the importance of which is considerable, especially in large theatrical productions, presents special difficulties to assure the fireproofing of all classes of fabrics, colored with all the materials that scenery painters now use, without risk of changing the colors.

It is this problem that we have ventured to attempt to solve, by a series of investigations beginning in 1912 and renewed after the war. The results have been submitted for approval to a special sub-committee, which emanated from the Commission established on December 15, 1913. We believe it will be useful to publish as widely as possible the conclusions of this work. Below is some historical information on the subject.

Historical.

As early as 1821, Gay-Lussac attempted to render fabric incombustible. He has stated the problem with such clearness that we believe it will be helpful to reproduce here the essential parts of his notes:

We mean by incombustible fabrics not fabrics which will be free from all change when attacked by fire, but those which by their particular properties or by proper preparation, do not easily take fire, do not burn with a flame, extinguish themselves and do not spread combustion. Wool and silk fabrics, and in general those of animal fibres, are not very combustible; while fabrics of hemp, flax and cotton take fire easily and burn with great rapidity. Consequently it is the fabrics of the latter class which it is more important to make incombustible. A fabric may

---

This article appeared originally in the February 22, 1922, issue of *Genié Civil* and is published with permission of the editor. Translation by Executive Office of the N. F. P. A.

be made incombustible and its destruction by heat limited to a simple calcination by keeping its surface from contact with the air, and by mixing with the combustible gases which the heat evolves other gases which are not combustible; for as is well known such a mixture, in the right proportions, cannot take fire.

The first of these conditions may be easily met by covering the fabric with some incombustible coating, such as an earthy substance, a salt; but, as the pliability must not be lessened nor the surface changed, one is very much limited in the choice of coatings. In fact, merely an earthy coating, unless it is in a very thick layer, will not sufficiently keep out the air, because of numerous interstices between the particles, and therefore the combustion of the fabric which it covers is not retarded.

The best coverings are those which are very fusible, for they run together at the first contact of the heat, covering the whole surface of the fabric and preventing contact of the air.

It is easy to satisfy the second condition, which we mentioned as necessary for making fabrics fireproof, by saturating them with volatile non-combustible material, such as ammonium chloride or sulphate. The vapors of these salts hinder the combustion of inflammable gases with which they come in contact, not only by diluting them, but also by absorbing heat in melting, thus lowering the temperature below that necessary for combustion.

Gay-Lussac concluded that ammonium chloride, sulphate, phosphate and borate, borax, or a mixture of these salts, were the most practical substances for making fabric fireproof.

Nevertheless, the practical problem was not solved, for, particularly as concerns theatrical scenery, substances must comply with a certain number of conditions besides those already indicated by Gay-Lussac:

1. They must not change fabrics or make them hygroscopic.
2. They must not injure colors used by scene painters.
3. They must be inexpensive and easy of application (therefore, not poisonous) and, in addition, adhere in some way to the fabric of the cloth so that they will not come off, even during much manipulation.

It is difficult to meet all these conditions at the same time. That is why the prize offered, in 1829, by the Society for the Encouragement of National Industry, to the inventor of a process making fabric and wood non-flammable, was offered in vain for six years in succession; renewed in 1879, it was not until 1880 that a reward of 1000 francs was assigned to M. Martin, inventor of a preparation of fireproofing mixtures based on ammonium chloride and sulphate, borax and boric acid.

The government authorities, on their part, had been busy applying to theatre scenery the fireproofing salts mentioned by Gay-Lussac.

On the 17th of May, 1838, G. Delessert, Prefect of Police, issued an ordinance prohibiting theatres from using any but linen and non-flammable paper scenery, to prevent, as far as possible, rapid spread of fire. The police ordinances of July 1, 1864, May 16, 1881, and finally that of August 10, 1908, now in force, have continued this regulation. But these regulations have hardly been observed in France, in spite of the efforts of the government and of those of Girard, former head of the municipal laboratory of Paris, who made an effort to extend the use of various fireproofing formulas, with little success.

How can we explain this undeniable fact? We must admit that the first fireproofing solutions gave only mediocre results, and Troost, in his report to the Society for Encouragement, showed that, shortly after the ordinance of 1838 had been put in force, an experiment of putting the flame of a candle to some curtains which had been made non-flammable,

resulted in their burning as if there had been no solution on them. This failure, officially confirmed, put in disfavor all the solutions proposed at that time.

But following the work of Martin and some others, it became impossible to deny the efficiency of some of the proposed new solutions. However, the ordinances continued to remain a dead letter. In fact the use of most of the fireproofing solutions sold in commerce had the serious drawback of changing most colors, and were a source of much trouble to scene designers and owners of theatres. In one instance the back curtain of a large opera scene was spoiled as a result of careless application of a fireproofing solution.

The reason for this failure lay in the fact that industrial concerns that carried on the sale and the application of fireproofing liquids were using substances really fireproof, but were not studying systematically the action of these liquids on the colors actually used by scene painters, including a number of organic colors. It is this problem that we have particularly tried to solve.

Fireproofing without Action on Colors.

In a previous study which we made in which we reviewed the various fireproofing solutions commonly used, we arrived at the conclusion that:

1. All the ammonium salts, whatever the acid from which they were derived, exerted a marked action on the "golds" which rapidly turned green on contact with them, whereupon it was necessary to eliminate ammonium salts.

2. Many scenery colors, made up of lakes of organic substances, are true colored indicators (*laque geranium*, eosine base or the sodium salt of tetrabromfluorescene), that is, depending upon the acidity or basicity of the particular solution, or better with the concentration of hydrogen ions, they undergo marked changes of hue very similar to the well known changes in the color of litmus.

That is why solutions of borax, having an alkaline reaction, although excellent for fireproofing, turn *laque geranium* to violet.

We have accordingly tried to produce a salt solution, neutral to the more unstable coloring materials belonging to the phthalein group.

We found that a solution of 6 parts of borax and 5 parts of boric acid fulfilled the desired condition and that this mixture, in contact with the most brilliant and unstable lakes, did not noticeably change their colors. And this solution, used under the conditions which we will mention later, is a very good fireproofing liquid, in the sense defined by Guy-Lussac, although it does not produce incombustible gases and only acts by excluding the surrounding air from the combustible fibre.

A cloth containing 45 grams of salt per square meter (1⅓ oz. per sq. yd.) did not burn, in prolonged contact with the flame of a blowpipe or an electric arc produced by a short circuit, or more accurately, it carbonized without emitting flames in any appreciable amount, and combustion stopped when the source of heat was removed.

In order to determine possible deleterious action which the fireproofing solution might exert on coloring matter, we subjected our material to conditions as severe as any which could occur in the work of scene painters. To do this we experimented by applying the colors

directly on the unsized cloth, so that the contact between the fireproofing solution and the colors would be as intimate as possible.

This trial was carried out in a small way, simultaneously at the laboratories and by scene painters in their studios, and also on a curtain of several square meters, of which part had been treated by the fireproofing solution and the rest left untreated. On this latter, a scene was painted under the direction of Messrs. Simas and Bailly.

We succeeded except in the case of two colors: *laque geranium* (eosine base) and light blue lake (Patent blue base*), all the others on which we worked remaining unchanged, even when we applied them directly and without sizing, on a fabric treated by the solution above mentioned. If before putting the paint on the curtain treated with the solution, the latter is covered with a sizing, which is the general practice, all the colors, including *laque geranium* and light blue lake, remain wholly unchanged.

Of the 28 colors tested, there were then only two which have showed any change in hue on direct contact with the fireproofing solution.

The only artist who used these colors advised that they gave unsatisfactory results, and others could be substituted, without inconvenience, particularly the fast reds† and diamond blues† used by his colleagues, which were not changed by the fireproofing solution.

Finally to replace the Patent Blue we proposed to the artist that he use the extra bright iron blue lake (Bayer) which is unaltered by the borax and boric acid solution and which, to quote him, "possesses exactly the effect of Patent Blue and is even more brilliant and intense."

It can be definitely concluded, therefore, that the proposed fireproofing solution, in every case, whatever the method of putting the color on the fabric, can be used without hurting the colors used by scene painters. We can even say that change undergone by any color, put on a curtain with the fireproofing solution, is a valuable indication to the artist who uses it, for it shows him immediately that he is working with an unstable color which will probably fade rapidly under the action of light.

The Fireproofing Solution Non-injurious and Permanent.

It was important, also, to determine that the fireproofing solution had no action on vegetable fibres. To this end, we submitted strips of various fabrics, in the direction of the warp and of the woof, to dynamometrical tests, before and after applying the fireproofing solution. Inspection was repeated after keeping the samples in a dry room heated to 40° C. for a month. In no case have we noted that a lessening of resistance of the fabrics resulted from the action of the fireproofing solution on the fibres.

We also left samples of the same fabrics in more or less humid atmospheres, some saturated with the liquid, and others simply dipped in water and dried. We found that the quantity of moisture absorbed was the same for both; from which it could not be considered that fireproofing fabrics, by this process, would promote decay and tend to weaken the seams.

---

* Probably Patent blue, Schultz No. 543.

† Probably such colors as Fast Red Schultz No. 166 and Diamond Blue Schultz No. 164.

Finally, we would point out that not only in the laboratory tests but also in practical tests in scene painters' studios and stores, we found that fabrics saturated with the borax-boric acid solution dried as rapidly as the same fabrics not saturated with the solution; in addition, the treated fabrics retained all their pliability.

At the present time, fireproofed painted scenes kept in our laboratory since 1913, have lost none of their resistance to flame and moreover their colors have not faded.

Practical Procedure for Fireproofing.

A. NEW CURTAINS AND FABRICS. FIRST PROCESS. New fabrics (linens, muslins, etc.) are easily fireproofed by moistening with the following solution:

Boric acid	50 grams (6⅔ oz.)
Borax (crystallized sodium borate).....	60 grams (8 oz.)
Water	1000 grams (1 gal.)

The fabric, well saturated with liquid, is drained and then hung up until completely dry. The kind of cloth commonly used for making theatre scenery takes about 45 grams of the salt mixture per square meter (1⅓ oz. per sq. yd.). Fabrics thus treated can be painted in the ordinary way, but, of course, one should avoid by all means washing them or exposing them to the prolonged action of rain.

The same process of fireproofing can be used for paper streamers, paper flowers, grass, etc., used for decorating halls, provided, however, that the paper is not too heavily sized and can absorb the liquid.

SECOND PROCESS. Scene painters having sometimes expressed a wish to fireproof the curtains themselves, and asked us to furnish them with a means of mixing the fireproofing liquid with the size, with a view to keeping down the labor cost, we have sought for a process which might give them satisfaction. In such a case the procedure is as follows: Dissolve in the hot sizing* 200 grams (7 oz.) of the following mixture: Borax 6 parts, Boric acid 5 parts, and size the curtain with a brush in the usual manner. To make the fireproofing effective, it is essential that the cloth absorb half a liter of sizing per square meter; if a closely woven and glazed fabric is used, the sizing must be worked in.

The first process (fireproofing of untreated cloth) gives more reliable results. If, as it is hoped, the use of fireproofed curtains and fabric becomes more widespread, it would be easy to fireproof the fibres in the fabric, the salts being added to the dressing.

B. SETS. In scenery storerooms of theatres there are quantities of backdrops and scenery not fireproofed. It was necessary to evolve a relatively simple process for fireproofing these sets when they are to be used.

This is easily done by spraying on the back of the scene (the side not covered with paint), in two successive operations, a proper fireproofing solution. The following method, tried on the scenes of one of our large

* Quantity of sizing used to dissolve the mixture is not stated in the original. We assume that the quantity must be such that about 1⅓ oz. of the fireproofing mixture be deposited per sq. yd., as in the FIRST PROCESS.—ED.

Paris theatres, has given very good results: The scene is hung up conveniently, and a solution containing 75 grams (2⅝ oz.) per liter of the mixture mentioned above (solution A) is sprayed on the back by means of a *Vermorel* machine or some similar machine in such a way that the curtain is evenly covered. The use of this solution, which is weak, is to soften the fibres so that they will more easily absorb the more concentrated second solution. Ten or twelve minutes after the first application, the second can be made in the same way, this time using a solution containing 150 grams (5¼ oz.) of the salt mixture per liter. This application should also be as uniform as possible, so that the scene shall be completely saturated.

Large back drops can be easily fireproofed in this manner by hoisting them with tackle. Begin to fireproof them on the upper part and raise them progressively the height of a section which can be reached. The operation finished, leave the curtain hanging to dry.

This process can also be applied to fireproofing lined curtains; the spraying is done on the painted side, but in this case, the process takes a little longer than in the case of single curtains.

We record the results of some tests on the scenes in question:

I. Scenery.

Surface: 4^m 4 x 4^m 4 = 19^{m2} 36 (23.2 sq. yd.)

First solution of 75 grams per liter (9.1 oz. per gal.): 3 liters 30 (⅞ gal.)

Second solution of 150 grams per liter (18.2 oz. per gal.): 4 liters (1.06 gal.)

Total amount of solid salts: 262 grams 5 + 600 grams = 862 grams, 5 = 43. grams 5 per square meter (1.28 oz. per sq. yd., say 1¼ oz. per sq. yd.)

The scene was dry after four hours (room temperature: 25° C. 77° F.)

II. Wings.

Surface: 7^m 8 x 1^m 8 = 14 square meters (16.7 sq. yd.)

First solution of 75 grams per liter: 2 liters 500 (.659 gal.)

Second solution of 150 grams per liter: 2 liters (.53 gal.)

Total quantity of solid salts: 487 grams 5 (15.6 oz.)

Quantity of salts per square meter: 34 grams 9 (1.03 oz. per sq. yd.)

III. Large Back Drop.

Surface: 6^m 7 x 9^m = 60^{m2} 3 (72 sq. yd.)

This test was carried out to determine the labor cost of such an operation.

First solution of 75 grams per liter: 11 liters 5 (3.04 gal.)

Second solution of 150 grams per liter: 8 liters 25 (2.18 gal.)

Time for the first fireproofing: 30 minutes

Time for the second fireproofing: 20 minutes.

A total of 50 minutes

Total amount of solid salts: 862 grams 5 + 1237 grams 5 = 2100 grams or 35 grams per square meter (1.03 oz. per sq. yd.)

Cost of Fireproofing.

The fireproofing of scenery already painted is evidently more costly than of new scenery, because of the labor cost which is involved. However, the cost is small, compared to the total cost of painted curtains, the latter being as a rule greater than 20 francs per square meter. The quantity of solid salts used averages about 40 grams per square meter.

Based on the price of 160 francs per 100 kilograms for borax and 340 francs per 100 kilograms for boric acid (September 1921), the cost of 1 kilogram of salt solution comes to about 2 francs 40, which is per square meter of curtain: 2 fr. 40 x 0, 040 = 0 fr. .096, or 0 fr. 10 in round numbers.

40 g per sq. m. = 1.18 oz. per sq. yd., making the cost of the chemicals about 2-3 of a cent per sq. yd. at current wholesale prices in U. S. Reckoning the labor at one hour for 72 sq. yd. paid at the rate of $1.00 per hour, the labor cost would amount to about 1 1-3 cents per sq. yd. The total cost of fireproofing old scenery would therefore amount to about 2 cents per sq. yd.—Ed.

Making a reasonable allowance of a few centimes per square meter for the cost of labor, it is clear that the extra expense of fireproofing scenery is small in comparison with its total value.

Fireproofing of Light Material.

In some theatres where there are a large number of supers, costumes of tulle, muslin and other light materials are frequently used. When these materials are of animal fibres (silk, wool, etc.) they are not very flammable, but it is a different matter when they are woven from yarn or fibers of vegetable origin (e.g., artificial silk). On the stage, the danger of setting this material afire is limited, because of precautions taken to prevent every chance of fire or accidental electric arcs; in costume storerooms and in dressing rooms, these dangers are much greater, either from electrical defects which are always to be feared, or from rank carelessness which cannot be prevented among the personnel.

There are many dressing rooms where a conglomeration of things collect in a small space and where large heaps of costumes are hung along the wall or piled in a trunk in the middle of the room. A fire starting in this pile of material, spreads with such rapidity that it is hard to stop without serious damage and perhaps loss of life. We still have before us the problem of using fireproofing solutions on colored dresses, but for white or light colored muslins and tulles the solution we have suggested for curtains (borax and boric acid) can be used to advantage. This can be done by spraying, but it is better to do it when the material is being starched or while ironing it. In the latter case, the starch should be dissolved in the fireproofing solution. Furthermore, when the cloth dresser wishes to do the fireproofing, he can use this solution to dissolve his sizing material.

Therefore as far as white or light colored muslins or tulles are concerned, the question is solved and their fireproofing can be accomplished in the same way as that of the fabric of scenery.

Fire Prevention Inspection.

By Frederick H. Cowles.
(Member N. F. P. A.)

It is not the purpose of this article to thoroughly cover the field of fire prevention inspection, but rather to summarize briefly conditions existing in some of the larger cities in the United States, with particular reference to activities of city fire departments.

Most large cities successfully employing fire prevention inspection depend to a great extent upon inspections made by members of the fire department, detailed for this work by the commanding officers of the company located in the districts inspected. Certain features of fire prevention inspection work involve technical knowledge difficult for the average member of a fire department, but a high degree of intelligence has been developed and can be still further developed through the establishment of a system of instruction for the members of fire companies, both in the fire houses and at fire prevention headquarters. This work is sufficiently advanced to be already adopted in some measure by certain cities, as in the city of Detroit, where instruction is given weekly, generally on a Saturday, to the members of the fire prevention inspection squad, who are not only given a course in the definition of hazards, but also in the various features of certain laws and ordinances.

There is a similarity of method employed by many cities, with perhaps a broader field in the city of New York than any other, where some 33 forms are employed for the purpose of investigating fully, checking up and correcting complaints received.

Cincinnati System.

Credit should be given to the city of Cincinnati for being a leader in establishing a fire prevention bureau, and there an excellent system has been developed. A form report is made by the firemen of the company inspecting. Another form indicates defects and hazards found by the inspector following the complaint, and five days are allowed to apply the remedy. In event of failure to correct bad conditions the report is sent to the fire prevention board for final disposition.

The city of Cincinnati also employs forms with small squares with a small printed notation referring to the particular hazard, such as gas, oil, acids, waste, hot ashes, chimneys, roofs, lighting systems, heating apparatus and miscellaneous. This particular form is for the use of chief officers only.

The Cincinnati bureau prepares a daily report showing the location of property and description of the property inspected, the owner, lessee or occupant, and the time allowed for remedy. It is signed by the inspector and countersigned by the supervisor of fire prevention.

Another form employed in Cincinnati is for the inspection of fireproof scenery in theatres, this being in the shape of a sticker pasted on the

scenery showing that it has withstood a blow-torch test and is flameproof. All scenery in the theatres in the city is tested as soon as it arrives.

A form is employed for a complete theatre inspection report and is made out at the end of each week, giving the names of the theatres and showing the number of pieces of scenery that the inspector has condemned or ordered out of the theatre, each day during the week.

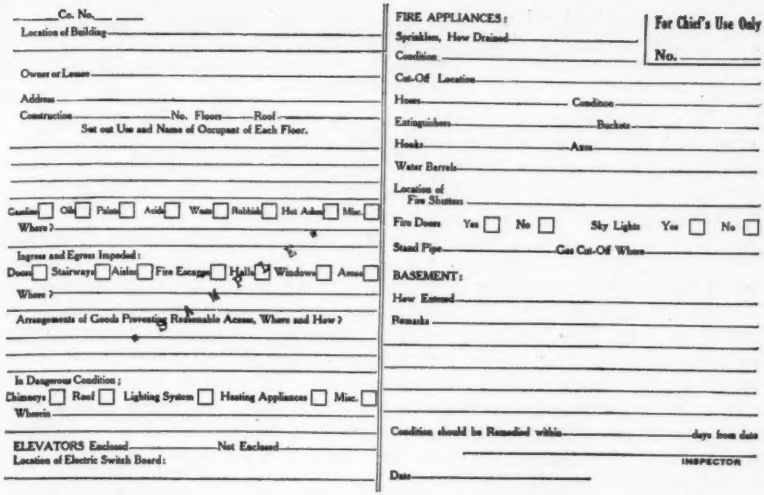
New York System.

In New York the fire prevention bureau is assisted not only by inspections made through the various fire companies in the five boroughs, but in addition to this, employs a large office force, filing system, and inspectors, both civilian and members of the uniformed force. This work is also assisted by the fire marshal's department in New York, employing approximately nineteen men. During the past two years this bureau has been overworked, due to the large number of incendiary fires, commonly known as business fires. Up to March 1, 1922, there were approximately 2000 more fires in greater New York, dating from January 1, than during the same period of 1921, and a large number of these fires were of incendiary origin.

The forms employed by the city of New York cover a complete inspection report of factory buildings; another form covering mercantile buildings, warehouses, office buildings and miscellaneous buildings. Another form used by the firemen in congested districts reports conditions and recommendations to occupants of buildings. New York appears to employ a form not employed by most of the other cities, and to the writer's mind a most important one. This is called Form 6 and is an inspection slip indicating what action has been taken regarding the conditions complained of by the inspector fireman in the particular district in which the company is located, and this copy is sent back to the commanding officer of that company informing him what disposition has been made of this complaint,—whether it has been investigated and found uncorrected or whether the hazard has been modified or eliminated. This enables the commanding officer of the company to judge of the particular conditions in buildings entered by the men in the performance of their duty, and if the hazard has not been corrected, may provide the means of protecting their lives, particularly in the storage of dangerous supplies or combustible substances, the overloading of floors, defective fire escapes, etc.

An inquiry sent to several cities as to what their opinion was regarding this particular form showed that the form was not in general use, but that it was considered a very good idea.

A summary of the entire field covered by fire prevention inspection in New York shows that the forms include re-inspection slips, process service on owners, miscellaneous violations, labor law requirements, interior electric fire alarm requirements, fire drill, gas control, jack-up letters urging compliance with pending orders, inspection of structural work through application to the building department, occupants, exits, dangerous conditions, druggists' permits, cleaning and dyeing requirements, oil stations, motor vehicle, repair shops, storage of combustibles, drugs, etc.



Co. No.
Location of Building
Owner or Lessee
Address
Construction No. Floors Roof
Set out Use and Name of Occupant of Each Floor.
Gasoline Oil Paints Acids Wax Rubbish Hot Ashes Misc.
Where?
Ingress and Egress Impeded:
Doors Stairways Aisles Fire Escapes Halls Windows Areas
Where?
Arrangements of Goods Preventing Reasonable Access, Where and How?
In Dangerous Condition;
Chimneys Roof Lighting System Heating Appliances Misc.
Wherein
ELEVATORS Enclosed Not Enclosed
Location of Electric Switch Board:
FIRE APPLIANCES:
Sprinklers, How Drained
Condition
Cut-Off Location
Hose Condition
Extinguishers Buckets
Hooks Axes
Water Barrels
Location of Fire Shutters
Fire Doors Yes No Sky Lights Yes No
Stand Pipe Gas Cut-Off Where
BASEMENT:
How Entered
Remarks
Condition should be Remedied within days from date
INSPECTOR
Date
For Chief's Use Only
No.

Form I used by the fire prevention bureau of the Cincinnati Fire Department. This inspection report is made by a uniformed fireman and is sent to the Bureau where it is checked, numbered and filed for future reference.

Detroit System.

Both Detroit and Chicago have developed the conduct of the fire prevention bureau along similar lines. Detroit, for instance, employs an inspection force, in addition to the inspection made by the fire companies, made up of members of the department, who are eligible for the position of lieutenants,—that is, who have passed an examination for promotion. They are obliged to serve at least six months in the fire prevention bureau and be confirmed in this work. The authorities of the city of Detroit are of the opinion that they are thus enabled to secure the more ambitious and intelligent type of men.

Here, too, are held schools of instruction on hazardous subjects and laws and ordinances, and it is believed that this system tends to keep the men of the department more ambitious for promotion and brushed up on fire prevention subjects. As fast as these men are promoted the next highest man on the eligible list is entitled to take his place, and the men who are promoted go back into the department for fire duty, and of course take with them an increased knowledge that should improve the service.

It is evident that this system is meeting with increasing favor, as it follows along the path of progress by which the fire extinguishing force of our great cities are being raised to a higher plane of intelligence, and fire prevention is being merged with fire extinguishing. It is more and more understood that it is equally the fireman's duty to prevent fires as well as to extinguish them, and the firemen have the advantage of a practical education in fire fighting that others can never have.

The city of Detroit also has an arson squad, composed of two members of the police department and detective division.

Other Cities.

It is surprising to learn that the city of Pittsburg has no regular bureau of fire prevention—at least none in operation up to March 1922, but here, too, a system of inspection is carried on by the firemen, and these complaints referred to the building department. No forms indicating action taken on the complaint are employed by that city.

In the District of Columbia, under the supervision of the Government, there are employed two inspections,—one made by the inspection force under the supervision of the fire marshal, and the other made by firemen detailed by fire companies. As in Cincinnati, Detroit, Chicago and New York, the follow-up work is done by the fire prevention office, designated in the District of Columbia as the fire marshal's office. No slip showing action on complaint is employed in this city but if the condition is not corrected a second report is made out. Where no disposition slips are employed the fire companies making inspection have no means of ascertaining whether the condition is corrected between the time of the first inspection and the re-inspection.

In the city of New Orleans weekly inspections are made of all commercial and manufacturing plants in the congested and suburban districts. These reports are sent to the office of the chief engineer, and give the location, the occupant, the owner and the condition referred to. If the complaint has been previously made and the condition not corrected on re-inspection an affidavit is made against the offender.

The state fire marshal of Louisiana operates independently from the city fire department and also makes inspections through his deputies who report to him direct.

In Rochester, N. Y., inspections are made by the battalion chiefs and captains of fire companies. Every other month the city district is inspected by two captains from each side of the river, and these reports are sent to the commissioner of public safety, but as the fire department has no authority in the matter, and considerable time elapses between inspections, there is an obvious defect in this system.

Under the administration of the commissioner of public safety in Rochester the superintendent of buildings is authorized to enforce the building code laws. No disposition slips are employed in this city, but in the opinion of the chief of the fire department these would be of benefit to the department and stimulate the work.

The city of Cleveland employs 14 fire wardens, each in charge of a district, and these are held responsible for the condition of their districts. Inspections are also made by the different officers of the fire companies. This system seems to have much to recommend it, with the exception that inspections by the fire companies are made when the business of the fire department will permit, and it would appear that the business of the department in preventing fires should be as great an objective as extinguishing them. If the commanding officer of a fire company cannot bring about a correction of the violation the warden in the district takes charge of it. The advantage of this plan is that it does away with

DETROIT FIRE DEPARTMENT---FIRE PREVENTION BUREAU Date_____ 192___

Building located at _____ **Stories** ____ **Occupied as** _____

VIOLATIONS and floor found on.
Aisles, insufficient or blocked
Ashes in wooden boxes, etc.
Acids, dangerous, not placarded
Baled paper, storing too much of
Chimney defective
Celluloid improperly stored
Doors or windows, blocked or nailed
Fire escapes, blocked or defective
No zinc under stoves, etc.
No hood or vent over ranges, etc.
No metal cans for oily rags, etc.
No metal bins for excelsior, etc.
Ovens, etc., not properly protected
Partitions, too near stoves, etc.
Rubbish in yard or building
Rubber hose on gas appliances
Smoke pipes, too near woodwork
Steam pipes, too near woodwork or stock
Stairways, blocked or nailed over
Storing explosives contrary to law
Ventilators full of grease
Windows to fire escapes, out of order

Questions.	Yes or No
Did you examine behind machines, ranges, benches, under stairs, dressing rooms, lockers, etc., for fire hazards?	
Are the bottoms of elevator shafts kept clean?	
Is boiler room kept clean?	
Are there any loose electric wires?	
Do they use paper shades on electric lights, or tin cup wires on nails, pipes, etc.?	
Do they use any oil or electric appliances which would be likely to cause a fire and did you order it protected?	
Do they use any substance which would be detrimental to firemen in case of fire? If so, what is it, where is it stored and what amount is carried in stock?	

Owned by_____ Business address_____
Lessee_____ Business address_____

REPORT ON THE FOLLOWING:

Is building sprinkled?_____ Condition of system_____
Has building stand pipe?_____ Has it hose?_____ Condition of system_____
Have they any other fire appliances?_____ What kind?_____
Did you recommend that more fire appliances be installed?_____ What kind and where?_____
Has building fire doors?_____ Have they fusible links?_____ Will they work_____
If not automatic, are they kept closed at night?_____
Is elevator enclosed?_____ Do gates and doors work properly?_____
Are openings through fire walls protected?_____
Are floors overloaded?_____ What floors?_____
What condition are skylights in?_____
Is there ladder to scuttle in roof of building?_____
Are all openings in floors protected?_____
What kind of heat is used, stoves ☐ furnace ☐ boiler ☐ central ☐
Condition good ☐ If bad, how and where?_____
What kind of lighting system is used, electric ☐ gas ☐ oil ☐
Condition good ☐ If bad, how and where?_____
Do they handle inflammable liquids?_____ How and where is it stored?_____
_____ Have they a permit?_____

Name of Occupant or VIOLATION and Floor Occupied
_____ on the ____ floor, Business_____
_____ on the ____ floor, Business_____
_____ on the ____ floor, Business_____
_____ on the ____ floor, Business_____
_____ on the ____ floor, Business_____

Regarding violations found interviewed_____
Construction of building_____ Condition_____
Remarks_____

Conditions to be remedied in____ days from_____ 192___ on re-inspection_____ 192
Inspector

Conditions were_____ Inspector No._____

This form is filled out by the Detroit Bureau inspectors, and if violations are found it is held by the inspectors until they are corrected. It is then filed in the Bureau office.

the necessity of burdening the central fire prevention bureau with innumerable small complaints that might easily be adjusted by diplomacy and a little persistency on the part of the company making the inspection.

It is interesting to note that on inspection slips employed by some cities appear copies of general ordinances or particular ordinances to which the matter refers. This is an advantage in convincing a property owner that the request for correction of hazards is backed by proper authority. This is also instructive to the general public.

Seattle, Washington, employs a fire prevention bureau similar to the city of New York. A systematic inspection is made of all buildings in the congested district. Outside of the congested district inspections cover apartment houses, dry cleaning establishments, garages, hospitals, hotels, theatres, and other places of public assembly. Inspectors from this bureau also supervise the installation of gasoline tanks, fuel oil tanks, acetylene generators, and all permits for the storage of explosives, fireworks, calcium carbide, etc. Such work cannot be performed until this inspection is made. Officers of each fire company inspect buildings daily and if violations exist notifications are sent on a printed form through the fire marshal, and a check-up inspection is made. The company's officer is not notified as to what disposition is made of the complaint.

It takes one regular inspector about three months to inspect the district to which he is assigned, and we can see the great value of the co-operative inspection work done by fire companies. It is evident that it will be practically impossible to employ a sufficiently large force to properly conduct this work unless assistance is given from the various fire companies, and as there is a great deal of moral suasion needed in certain cases it is more than probable that a request for the correction of a minor infraction of the law made by a fireman or officer in the particular company in which the hazard is located will be observed, because of the acquaintance of the owner with the officer of the fire company, as there generally exists in most company districts a kindly feeling towards the officers and members of the fire company located there.

The city of Chicago inspects through uniformed firemen assigned to the bureau of fire prevention, a system similar to that employed in Detroit, and in this case the first 35 men on the lieutenant's list for promotion are employed. There are four civilian fire prevention engineers employed who co-operate to instruct the firemen.

If a fireman finds a violation of fire prevention regulations, a written report is sent to the bureau of fire prevention, and (similar to the system employed by other cities) an inspection from that office is made and a letter covering all violations sent to the responsible persons. This letter is checked up, and if corrections are not made within a reasonable time, depending upon the seriousness of the violation, suit is commenced.

Boston, San Francisco, Los Angeles, Buffalo, and numerous other cities have followed more or less along the lines laid out by the cities above mentioned. In Massachusetts, the state fire marshal's department exercises considerable authority in the city of Boston; the writer cannot say that this appears to him to be the wisest course, as he believes in a policy of local control and responsibility. Oregon, for instance, while employing a state fire marshal's department, has adopted a policy of non-interference with the local affairs of city ordinances, unless appealed to by the departments of public safety. It would be well to consider this in its relation to the desired end. There has been so much division of authority in the past in the city of Boston that the best results do not appear obtainable. The building department exercises jurisdiction over places of public assembly,—theatres for instance,—while in other cities,—New York for example,—there is a bureau of public assemblies connected with the fire department.

Conclusions.

A fair deduction to draw from an examination of the situation is that members of the fire department who are held responsible and whose sworn duty is to protect life and property should be encouraged and trained in fire prevention work. It would be a strange commentary on human nature if men who are obliged to endanger their lives in entering buildings in the performance of duty should not be as deeply concerned, and even more so perhaps, in correcting hazardous conditions than a civilian, however conscientious, who holds a fixed position, and who has little chance of promotion and is in practically no danger of losing his life in the performance of his duty. The high standard of intelligence existing in the fire departments as compared to twenty-five years ago is a

strong indication that we should follow this line in developing fire prevention work.

In summarizing the possibilities of success of fire prevention inspection as conducted by various cities, personal experience has led me to believe that the contributing causes of failure to obtain the best results are due to a number of things. One of these is division of authority and responsibility. Another is of course ignorance of the general public, with the usual attributes of greed and carelessness always present. Of good laws there appears to be no dearth in most cases, but it has been a long step from the existence of the law to the enforcement of the law. There does not appear to be a proper realization of the full responsibility for criminal neglect in relation to fire causes, and for incendiary fires, on the part of our courts and juries.

Another factor that appears, particularly in small communities, is the unenviable position occupied by the chief of the fire department, who is subject to removal by some political body if he treads on some one's toes, and this I find has restricted, to a considerable extent, the enforcement of proper regulations.

Finally, inspection reveals in certain cities conditions that are somewhat puzzling, in view of the serious fires that have occurred in these communities in the past. San Francisco, for instance, permits private garages in the basement of dwelling houses, and to the extent, I believe, of many thousands of such dwellings, and in the rear of these basements, in close proximity to the motor car itself may be found gas heaters with pilot lights burning day and night! Further comment is unnecessary.

New York Central Pier Fire.

By W. F. Steffens.
(Member N. F. P. A.)

Pier 103-D at the West 60th Street freight terminal of the New York Central Railroad, New York City, was partly destroyed by a severe fire which broke out on the morning of August 12, 1922. Several freight cars were also badly damaged. Exceptionally good work on the part of the fire fighting forces prevented a more serious conflagration.

Construction.

Pier 103-D is supported on timber piles and bents, on which is constructed a two-story shed of dimensions 94 ft. x 424 ft. The shed is supported by steel columns and roof trusses, with sides of corrugated iron and roof of timber planking and pitch and gravel covering. The planking for the second story is supported on steel "I" beams. Timber sheathing of 2 in. x 6 in. planking spaced 6 in. clear between planks affords protection to a height of 8 ft. along the side walls against thrust of freight piled adjacent to it.

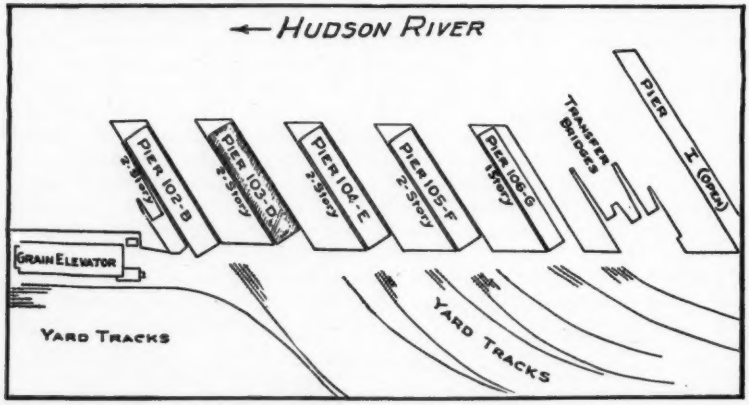


Diagram showing location of Pier 103-D at the West 60th Street terminal of the New York Central Railroad, New York City.

Two tracks extending the length of the pier through the center of the shed enable handling of cars for movement of the freight. In each side of the pier shed, at the first floor, are nine doors, three of which are over inclined ramps over which freight trucks can be handled to boats during time of low water. On line with the tops of doors is a series of windows each about 2 ft. 6 in. x 4 ft. 6 in., guarded with metal rods. To serve the

The heavy concentration of tugs delivering high power streams into the pier literally drowned out the fire.

second story, hatchways provided with large doors are located in each of the side walls. Barrel elevators afford communication between the first and second stories. The roof is pierced by skylights.

Beneath the main deck the transverse bents supporting the pier are sheathed with heavy planking to the level of low water, to prevent floating trash gathering between the supports. Longitudinally with the pier extends to high water line, at each line of interior columns, a solid bulkhead of 12 in. x 12 in. timbers bolted together, on top of which bulkheads the columns are supported. The presence of these longitudinal bulkheads is to be especially noted as will appear later.

Story of the Fire.

On the night of August 11th there was on the pier freight to the extent of forty-five carloads, and there were on the tracks twenty-one box-cars, four of which were empty. A steam propelled barge was loaded from several of the cars on the pier, and a non-propelled barge was also loaded in the early morning hours of August 12, by the night gang.

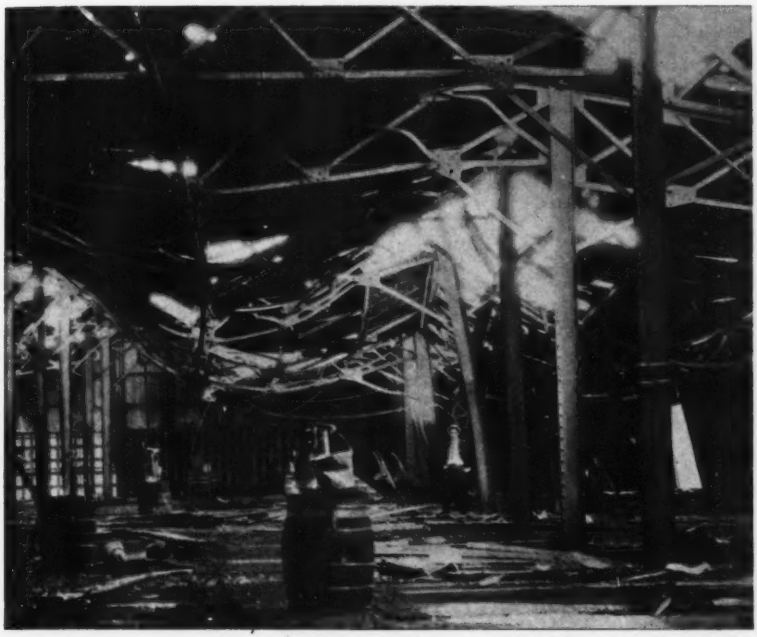
The night force quit work at 6:50 A. M. and their checker or foreman reported conditions as normal at about 7:00 A. M. The watchman operating the key station at south side of the pier at 7:10 A. M. also found conditions normal. At about 7:15 A. M. laborers of the day force assembling trucks for their gangs discovered fire burning briskly at the south face of the pier, at a point approximately thirty-five feet from the easterly inclined runway, in front of a closed door. At this point there were piles of jute that had not been moved from the pier the day before, as was expected. The local fire alarm was given from the whistle of an adjacent grain elevator. An additional alarm was sounded from an auto-

matic telephone system recently installed for this purpose throughout the terminal, which line terminates in Grand Central Terminal, at which point it was relayed by direct wire to the New York City Fire Department Headquarters. Within five minutes from the time that the City Department received the alarm the first apparatus arrived at the land end of the pier and had hose lines connected up delivering water on the fire.

Simultaneously with giving the alarm on the automatic telephone, the employee at the adjacent freight office that had turned in this alarm also advised tug despatchers at the freight pier north of the fire. Within three or four minutes several tugs had arrived and promptly removed floating equipment from both slips adjacent to the burning pier. So perfect is the communication between their tug despatching points that within a comparatively few minutes more there were fifteen New York Central Railroad tugs docked along the north side of the burning pier, head-on, so as to make practically a solid wall of tugs, each delivering high-power streams into the burning pier though the various openings afforded by the doors and windows, and eleven tugs of other railroads and towing companies, together with four city fire boats, were also delivering water on the fire. Still other tug boats reported for duty but could not be used direct at the pier, although they assisted by wetting down the pier structure immediately south of the burning pier, to protect it from radiated heat and the possibility of burning embers being blown against it. Thus, within a comparatively short time from the discovery of the fire there were in effective service thirty pieces of floating equipment and twenty land steamers, all delivering water at their maximum capacity and literally drowning out the fire, which, on account of character of construction of the pier and the jute and other material handled thereon, threatened originally to become a conflagration.

It has been noted above that at the time of the fire there were twenty-one cars standing on the pier, seventeen of which were loaded. Switch engines promptly removed seventeen of these cars from the blazing structure so that they could be extinguished conveniently by land forces. Four of the cars could not be removed as one of them was derailed due to a barrel of grease rolling from the car and jamming between the face of it and the adjacent platform. These cars were uncoupled from the string by the brave action of a brakeman. He entered the pier under the protection of hose streams at a time when it was considered dangerous to do so by experienced members of the Fire Department. Curiously, after the fire was extinguished, this car containing grease was damaged only on the exterior, and the contents were accepted by the consignee as undamaged.

The zone of intensity of this fire was naturally in the vicinity of the point of origin where it burned through the deck of the second story and through the roof, damaging the steel framework and roof trusses at this section, so that total replacement will be necessary. The fire also swept riverward, not only by the natural draught created and the character of the contents, but stimulated, undoubtedly, by a northerly wind. The fire burned downward at the zone of maximum intensity, but was materially checked in its spread by meeting the solid wall of 12 in. x 12 in. timbers above referred to while describing general construction of the pier. This emphasizes again the value of fire breaks of some character in the design of pier structures.



Interior of the pier showing condition of unprotected steel beams.

Various possibilities were thoroughly analyzed in connection with the cause of the fire. Electric wiring was entirely in conduit so that this possibility was promptly excluded. The possibility for sparks from river equipment was also soon eliminated. While it may have been possible, it is quite improbable that a lighted match or cigarette could have been thrown into the shed at the jute bales, by some passer-by, along the face of the pier. Interior causes seemed more probable and were finally narrowed to the possibility that some party had either lighted a match or had been smoking and discarded the cigarette or match. The discovery of metal fittings that had originally accompanied a shipment of enamelled bath tubs, hidden in the bales of jute near the point of origin, indicated a possible attempted pilfering operation, and that the guilty party had lighted a match to more definitely determine the location when attempting to remove these articles from the pier property.

Conclusions.

The fire most graphically illustrates the very valuable service that can be rendered by floating equipment in fighting fires of this character, in conjunction with the land forces. The New York City Fire Department handled the fire from the time that the City Department arrived in such creditable manner than the loss was limited to less than $250,000. It is believed that this fire ranks among the best handled waterfront fires in recent years.

Some Fundamentals of Safeguarding Life from Fire.*

By C. Heller, Consulting Engineer.
(Member N. F. P. A.)

Safety is a relative term. There is no absolute safety, but there is no reason why every structure occupied by human beings should not be built so as to make safety to its occupants reasonably positive in case of fire. How to establish the degree of safety that at law would be called "reasonable" and therefore properly demandable by statute or lawful order is a matter of engineering opinion which is by no means uniform.

Many articles have been written on the dangers to life from fire. Some have been of a general character and others have been more of the nature of a specification for exits. The purpose of this one is to present and explain the underlying principles involved in the causes of loss of life from fire so that those who have occasion to study the subject or are responsible for the safeguarding of human life may gain a more intimate knowledge of where and in what manner the largest losses occur, how death ensues, and the fundamentals of the engineering problems associated with protection to occupants of buildings, and thereby be better qualified to undertake the preparation of laws and regulations for the purpose of providing safety from fire.

Safety from fire is so intimately associated with our daily life that practically every one has opinions on the subject. These opinions are often founded on erroneous assumptions and have led to practices unsound in principle which have served as precedents for many laws now in force, for few people have any definite knowledge of the many ways in which fire indirectly causes death, the extent of fire fatalities in the United States, how they occur, and in what class of structures the majority of lives are lost. Only an analysis of the data on these subjects, by indicating the relative importance of the various phases of the problem, combined with a knowledge of building construction, particularly as it applies to the design of exit facilities, can intelligently direct the work that will make possible the reduction of the present unnecessarily large toll of human life sacrificed to fire.

Loss of Life Statistics.

Although figures are published from time to time purporting to give the annual loss of life from fire in the United States, the writer has not been able to find that they are based on reliable information. Those which have been issued of late usually set the loss at about 15,000 persons, a figure which the writer believes considerably exaggerates the true conditions.

* Copyright, 1922, by C. Heller.

The most authentic and nearly complete data is that collected by the United States Bureau of the Census which during recent years has compiled mortality statistics over an area containing about 77 per cent of the total population of the country. The figures in the first table that follows are those of the Census Bureau converted to the equivalent of the total losses for the entire country. It segregates deaths resulting from fire into two classifications: Conflagration, No. 166, and Burns, No. 167. The former covers death from any cause following the burning of a building, or a prairie or forest fire, and is the usual conception of loss of life from fire. The second group includes death from burns due to direct ignition of the person or clothing without anything else necessarily being first set on fire, as for example a child falling into an open grate, or clothing igniting from a candle or being ignited by the explosion of a lamp. This classification also includes death from industrial burns as from corrosive substances or X-rays, and from scalding by steam, none of which have any connection with fire.*

There is no way of determining what proportion of the cases reported in group No. 167 are deaths from fire, but even if all were the result of fire, which it is necessary to assume in order to make any use of these figures at all, the total of both groups would still be only two-thirds of the quoted figure of 15,000 and with the possibility of the actual deaths from fire being but one-half of that number.

DEATHS IN THE UNITED STATES — TOTAL AREA

from	1916	1917	1918	1919	1920	5-year average
Group 166, Conflagration	1489	1576	1799	1205	1253	1465
Group 167, Burns	8087	9304	8419	7902	7835	8309
Total	9576	10880	10218	9107	9088	9774

The census statistics include all deaths where fire is the direct cause, but when death ensues from conditions which the fire produced the casualties are sometimes placed in other groups. For instance, if a person had a weak heart and died after having been in a theater panic, the death would be classified among the diseases of the heart; similarly the death of a person from pneumonia contracted from exposure during a fire would be placed in the diseases of the respiratory system, but where the individual dies as the result of injuries sustained at a fire the death would be included in group 166. The total mortality chargeable to fire by the census officials is therefore not as complete as that of the fire protectionist by whom all deaths are attributed to fire which would not have taken place had the fire not occurred, but the census figures also include fatalities

* These titles are itemized as follows: No. 166, Conflagration: Conflagration (to include all injuries of whatsoever nature resulting therefrom); crushed at fire (conflagration); fire (in sense of conflagration); inhalation of smoke (burning building); jumped from burning building; suffocation (burning building). No. 167, Burns: Burn (conflagration excepted, of any organ or part) by boiling liquid, water, coal oil, corrosive substance, fire, gasoline, kerosene, petroleum, steam, sulphuric acid; burn by vitriol; dermatitis actinica, dermatitis ambustionis; effects of corrosives, radium, X-rays; explosion of lamp; lamp accident; scald (of any part of body), scald by steam; sunburn."

from other causes than fire, so that the totals of the two groups enumerated are probably the closest approximations of the actual total life loss from fire that can now be made. They show a present death ratio of 86 per million of population. It is interesting to note from these statistics that during the past twenty years there has been practically no change in the death rate under the first classification (Conflagration), but that the rate under the heading of Burns has gradually diminished from 84 per million of population in 1900 to 74 in 1920.

While the losses in a single large city or even in one state are not an index to the losses over the entire country, they are of interest. According to the reports of the fire department of the city of New York, there were 723 deaths from fire in that city during the six years of 1915 to 1920,—an average of 121 per year or the equivalent of 22.38 deaths per million of population. On this basis the annual life loss for the United States during the same period would be about 2298. In the city of San Francisco, with a population of about 500,000, the deaths from fire for the past four years have been 31, an average of eight per year, or 16 per million of population per year.

Probably the most culpable form of negligence causing the sacrifice of life to fire is the lack of exits. While such fires and those resulting in the loss of several lives create the greatest amount of public agitation, they are comparatively few in number. By far the greatest part of the annual life loss occurs in the many small fires in which one or two die and which attract only passing comment. This is shown by the following table of 426 fires recorded by the writer.

Deaths per Fire and Percentage of Total.

	No. of Fires	Lives Lost	1 Death		2 Deaths		3 Deaths		4 Deaths		5 to 9 Deaths		10 or more Deaths	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dwellings	195	398	122	62	25	13	15	8	12	6	21	11	0	0
Non-dwellings	231	2141	73	32	34	15	26	11	13	6	52	22	33	14
Total	426	2539	195	46	59	14	41	9	25	6	73	17	33	8

At first glance these figures give the impression that the life losses occurring in dwellings are smaller in number than those in other buildings. That is true only in so far as the loss per individual fire is concerned, but not the aggregate loss; for the fatal dwelling fires over a fixed time outnumber those of all other occupancies combined. In the United States dwelling house fires, together with flats and apartments, constitute 65 per cent of the total number of fires. The fires from which the table was compiled are those of which the writer has a record and which extend over a period of many years and include such catastrophes as those occurring in the Iroquois Theatre, the Collinwood School, and the Asch Building,* which greatly add to the total of losses in buildings other than dwellings. It must be remembered also that prominence is generally given only to the more noteworthy fires, particularly those in which there is heavy life or property loss, so that thousands of lesser ones escape unnoticed or are not reported in the fire records. Were complete statistics available they would show that the majority of lives are lost not, as is commonly supposed, in industrial buildings, theaters, and places of public

* In these three fires alone, 901 persons perished.

assembly, but in the home; that the next greatest losses occur in institutional buildings (hospitals, orphanages, reformatories, and similar occupancies); and that the victims in both groups are mostly women and children.* In the home, they generally lose their lives as the result of carelessness or ignorance. The lighting of the kitchen stove is still done with gasoline. Matches are still regarded as children's playthings. Children still are locked in the house alone while their elders go to the movies. The gas leak is still hunted with the light of a candle. In institutional buildings, most of the disasters are due to poor construction and the gross negligence of those in charge, a sad commentary on our system of social organization.

In fires causing the loss of 1550 lives, a large number of which occurred in industrial and public buildings and in regard to which complete information was available, the writer found that 64% of those who perished were women and children, 36% were men. According to the more complete data of the United States Census Bureau, which while not giving the exact total number of deaths does give the correct relationship of the losses by sex and age, 61.2% of all lives lost in 1920 from fire and burns were children under 20 years of age. Of the total deaths, 42% were children under five years of age. For the five-year period of 1916 to 1920 the losses were:

Men	20%
Women	21%
Children	59%

Notwithstanding the fact that the greatest number of lives are lost in dwellings, the largest individual losses are in other buildings, and as the potential hazard is in proportion to the number of persons gathered in any one building the continued study and enforcement of fire safety precautions is not only justified but imperative and must not be relaxed.

The foregoing indicates that the loss of life from fire in the United States probably does not exceed 10,000 persons a year, a huge unnecessary economic waste and a terrible toll of human suffering; that the majority die not because they are caught in burning buildings but by their clothes being set afire, so that, therefore, loss of life is principally through the individual's own fault,—carelessness; that more people perish from fire in their homes than elsewhere; and that women and children constitute 80% of the total loss. The state through its legislative and police powers regulates building design and construction, in some places well, in others indifferently, thus affording full or partial protection against the fire hazards created by poor construction or lack of exits; but if any material reduction in the waste of human life is to be brought about, the state, or private agencies, will have to educate the people at large of the dangers of their many careless habits and penalize those who are deliberately negligent.

---

* Even in New York, the largest manufacturing city in this country, 76.6% of the lives lost by fire in 1920 were in buildings in which the victims slept and not where they were employed or went for amusement.

Causes of Death.

Fatalities from fire can be segregated into two main groups:

1. Those in which the individual sets himself on fire by igniting his clothing or by causing an explosion, and which are due to the ignorance or negligence of the victim.
2. Those in which a structure or its contents is first brought to a state of combustion through circumstances over which those killed may or may not have had any control.

The frequency of the former is to be reduced by education; the elimination of the latter lies in the field of engineering and presents more specific problems. It is with these that this article is chiefly concerned, namely the relation existing between construction and the loss of life from fire.

In order to provide necessary safeguards to life, the various ways in which fire causes fatal results must be kept in mind. Fire produces death,

Directly by:

1. Burning by contact with the flames.
2. Destruction of a major portion of the epidermis. (At least two-thirds of the surface of the skin is necessary to sustain life through its removal of toxins formed by the body.)
3. Inhalation of flames, thereby consuming the lining of the lungs and stopping respiration.
4. Inhalation of the gases of partial combustion, principally carbon moxoxide which is a poison.
5. Inhalation of smoke and gases of complete combustion, principally carbon dioxide, which cause asphyxiation through the exclusion of oxygen.

Indirectly by:

6. Jumping from burning buildings.
7. Being crushed or trampled in panic.
8. Collapse of building during fire.
9. Injuries received other than burns; or secondary causes following injuries (infections, exhaustion, shock).
10. Failure of exterior fire escapes (falling off vertical ladders, being crowded off fire escapes, dropping from ropes out of windows).
11. Heart failure due to excitement.
12. Invalids and convalescents being unable to withstand mental or physical strain due to weakened condition.
13. Entering burning building.

On account of the lack of completeness of the few records now being kept and because the fire itself so often destroys the evidence, it is impossible to give any indication of the ratio that the different causes bear to the total number of deaths. In the larger fires it is probable that the majority of the fatalities are produced by suffocation and by the injuries sustained in panics, while in the great number of dwelling fires in which one or two individuals succumb, death generally results from direct contact with the fire. At the same time it should also be remembered that both life and property can be destroyed by air heated to a high temperature without necessarily being touched by the flames themselves, and that such heated air may be carried a considerable distance from the seat of the fire.

Relation of Life Loss to Property Damage.

The magnitude of a fire seems to have little bearing upon the extent

of the life loss. In many fires involving only moderate property damage there has been considerable loss of life, whereas in large fires, especially those that have reached such proportions as to be called conflagrations, there has been little or no life loss, and the few who have perished in these fires have generally lost their lives through their own fault by entering burning buildings.* This is a common cause of fatality which will always exist and is due to heroism, lack of judgment, or impulses resulting from temporary abberration. It is unavoidable and only in one case has any connection with the preventable causes of loss of life from fire as related to construction, and that is when firemen or others lose their lives in endeavoring to save people trapped in buildings, a condition which seldom arises where sufficient means of egress are provided, although sometimes people become trapped by delaying their departure so long that access to the exits is not available when they decide to leave. This is a deficiency of judgment, not of construction.

This type of life loss is not within the scope of this article. Neither are losses in forest fires, railroad accidents, nor in fires aboard ship or in mines, nor those resulting from the explosion of substances whose chemical composition can be changed by detonation, percussion, or compression and which are normally classified as explosives in distinction to the instantaneous ignition of non-explosive materials such as flour or coal dust. But losses from the latter cause and those due to the explosion of gases of partial combustion created by fire, such as those evolved by the burning of nitrocellulose, are included.

The reduction in number of disastrous fires involving heavy loss of life during the last decade, in the writer's opinion, cannot be attributed so much to the stricter egress requirements now in effect as to the general improvement in structural design, the greater use of non-flammable materials in construction, and the application of modern business methods with their increased attention to good housekeeping, thereby eliminating many of the elements favoring the ignition and rapid spread of fire.

In specifying requirements for fire protection there is a tendency to confuse safety to life with property safety and it is often difficult to draw the line of demarcation. Most devices protecting property indirectly protect life by retarding the spread of fire, but not all of them. For instance, protection against exposure fires has no effect on the life hazard because occupants would be out of the building before any real danger occurred. Also walls, doors, and construction that are capable of withstanding the attack of fire for four hours have no additional value to safeguarding life over those that give one hour protection, for within that time all persons must be out of the building or be lost. As will be shown later, the interval between the alarm of fire and the time when it is assumed all of the occupants must be out of the building if their safety is to be assured, is comparatively short. Any construction which checks the spread of flames beyond that interval protects property but generally offers no further protection to life.

Where safety to life is concerned the same dependence cannot be

* In nine prominent American conflagrations during the past twenty years, including those in Baltimore, Salem, and Paris (Tex.), which destroyed property valued at $83,000,000, there was no loss of life.

placed upon the fire department as in the case of the protection of property, for unless the loss of life is large it usually occurs before the apparatus is in operation. Every building should therefore stand on its own merits with respect to the safety of its occupants, and the necessary precautions for such safety should not be slighted by relying on outside aid, the timely arrival of which is always a matter of chance.* Those who are interested in the protection of property too often fail to appreciate the importance of the life hazard, for if on the outbreak of fire lives are imperiled the first duty and impulse of every fire department is to rescue those in danger, to the temporary neglect of the extinguishment of the fire. Hence, if the entire attention of the fire fighting forces can be directed to combatting the flames immediately upon their arrival, the property damage will be proportionately diminished.

Caution should be exercised in assigning credit to fire extinguishing appliances on the property. The records show considerable loss of life due to people trying to extinguish incipient fires instead of devoting their efforts to saving their own lives or those of others, and failing to summon immediately the public fire department.** At the present day there is but one extinguishing device which has definite value in diminishing the life hazard and that is the automatic sprinkler. Its merit lies in the fact that it operates without the aid of any human agency, automatically discovering and checking the fire at its inception and at the same time sounding an alarm apprising the occupants of the building that it is on fire.

It is often difficult for some people to understand how fires can start in buildings of superior construction, and still more so how they can gain any headway in such structures. Therefore they conclude that any attention to means of egress is superfluous. But the fact remains that fires do occur in the best of buildings, so that regardless of construction or of fire extinguishing equipment, the presumption should always be made that fire will occur and the question asked, "Have reasonable precautions been taken to assure safety to life when the fire does take place?"

The Theory of Egress.

Even though a building be unsafe, a fire therein, even of considerable extent, may not result in any casualties. Only under certain combinations of circumstances will fatalities ensue. Two conditions, either of which is essential to such a situation, are that the premises are constructed or maintained in such a manner that smoke and flame will spread with excessive

---

* A fire started about 9:30 in the morning in a four-story brick factory building having two exterior fire escapes but entirely lacking decent exit facilities. Although a fire station was directly opposite the building and a company was in its quarters at the time, twenty-five girls and women lost their lives. (Newark, N. J., Nov. 26, 1910.)

** When fire was discovered in an old three-story hotel in Cheyenne, Wyoming (1917), about 9:35 o'clock in the evening, the manager and employees tried to extinguish the blaze without calling the fire department. The alarm was finally sent in at 9:59 by a passerby who saw the flames. Six people perished. It is reported that had the department been called when the fire was first discovered there would have been no life loss.

rapidity, or a lack of exit facilities, or both together. Both of these conditions are preventable, and being removed all the other circumstances can exist simultaneously without any loss of life or undue injury on the occurrence of fire.

It is with these conditions that the engineer is particularly concerned. All structures should have sufficient and properly designed exits so that when fire breaks out there will be no casualties due to lack of means of egress. But the provision of adequate exits is no proof against fatalities from secondary causes resulting from the fire. Hence the presence of sufficient exit facilities even in a well built structure is no excuse for carelessness in its maintenance by permitting unnecessary hazards or the locking of exits. The idea that mere number of exits, stairways, or fire escapes assures safety is entirely too prevalent. Neither does an alarm system, nor a fire drill, nor extinguishing equipment, however good it may be, guarantee security. It is only through the correct combination of properly designed, built, and placed means of egress, together with a sufficiently high standard of upkeep, and such other special provisions as may be necessary for each specific type of occupancy, that those who are within a building are given a real chance to escape uninjured on the outbreak of a fire.

Where by the nature of articles handled explosions or flash fires may be expected or where fires will produce large volumes of poisonous gases, the safety of occupants is not so much dependent upon adequate exit facilities as upon the precautions taken to prevent the occurrence of fires and upon the installation of appliances for their automatic control, for in such occupancies the rate of ignition is so rapid that difficulty may be experienced in reaching the exits.

The theory upon which the exits in buildings are generally designed is that of providing sufficient emergency exits in case the ordinary ones cannot be used. Fundamentally, of course, this is the correct principle, but it has led to the neglect of sufficient attention to those exits which are traveled in the routine usage of the building. *On becoming aware of fire, the first impulse of people is to seek the egress which they have been accustomed to use. Few know where emergency exits are located, and in the excitement of a fire often have difficulty in finding them. This makes it of the utmost importance that the stairs, elevators, and passageways ordinarily used be built to exclude smoke and flame so that they in preference to all other exits furnished will be usable when fire breaks out.* Whenever it becomes necessary to make use of the emergency exits the danger of casualties increases. An exception to this statement is where fire drills are so conducted that those taking part in them successively leave the building by each of its exits and thereby become familiar with them all.

The practice so common in public buildings of exposing the main stair and elevator shafts to smoke and flames and then furnishing in out of the way places emergency exits of good design is to be condemned. Where large ornamental open stairways form a part of an architectural scheme, other enclosed stairs should be in the immediate vicinity and given sufficient prominence so that those who use the building will be acquainted with them.

The importance of enclosing vertical openings is not only to afford protection to those within them against the effects of smoke and so that on their way to the street they may safely pass through floors on fire, but also because if open they are the greatest contributing factor to the spread of smoke and flame, thereby cutting down the time in which escape can be effected. As early as 1887, when elevators were a novelty, Wm. Paul Gerhard wrote of the importance of enclosing both stair and elevator shafts. It is surprising that thirty-five years later it is still necessary to preach the same doctrine. The far reaching effects that may result from neglecting the enclosing of vertical shafts are evidenced by the opinion of the committee of engineers who investigated one of America's greatest conflagrations: "The Baltimore conflagration is directly chargeable to unprotected floor openings. Had the stair and elevator openings in the building where the fire originated been properly protected, there is every reason to believe that the fire department would have been able to control the fire at the start."* Enclosing the stair and elevator shafts does not exceed one per cent of the total cost of fire-resistive buildings.

Panic.

In nearly all of the great fire catastrophes, except those originating in explosions, panic has been primarily responsible for the long list of fatalities.

The unexpected sounding of any form of alarm of fire will create a condition of mild excitement in people in the best of health and more intense excitement in those who may be temporarily or constitutionally weaker, which when they start towards the exits causes them unconsciously to seek the means of travel through which they normally enter and leave the building. Upon perceiving that such passages are not accessible or that they cannot be used, this excitement may become so intensified as to reach the state of panic. Under normal conditions people's actions are the result of the use of their reasoning powers, the product of their conscious minds, and these are used in accordance with their intelligence. But when under the stress of emotion, a blocking of the conscious thoughts or processes takes place, which if sufficiently strong causes a temporary loss of reasoning power, and when the emotion is that of fear produces the condition termed panic. Fear is the feeling or emotion aroused through a sense of danger. There are fears of various types and intensities. The extent of agitation or lack of self control of those under its influence depends upon the dread of that which is producing the fear. Of the natural and normal fears those of torture and of death are probably the strongest and most deep-seated in man, and these are the ones that are aroused through terror of being burned to death. Hence the loss of self control of the individual or crowd panic-stricken by fire.

The interference with reasoning power may be partial or complete, leaving the individual partly or entirely under the control of his subconscious mind. He will then act according to the impressions that have been unconsciously formed in his mind when in the normal state. Having already used the usual means of access and departure of the building while

* Report on the Baltimore Conflagration by the Committee on Fire-Resistive Construction of the N. F. P. A., 1904.

in the latter condition, he will therefore in the state of excitement attempt to do so again, *and if they are usable will escape uninjured whether in a highly excited condition or not.* When the fear is mild a person will still retain possession of his ability to reason and therefore act in accordance with his best judgment; and if the ordinary exits cannot be used, he may make several attempts to find different means of escape. But if he is excited, or becomes so upon finding that his first attempt at departure is unsuccessful, he can no longer seek a second or third exit with the same calm as when fear is not present, and his ability to escape from a perilous situation, if dependent upon the exercising of good judgment, will decrease as the agitation increases.

The state of panic may be reached through progressive agitation, or may be created almost instantly as when someone yells "Fire!" in a crowded hall or theater. Fear has then taken complete hold of the individual; having lost the ability to reason, he acts impulsively, and when panic is created suddenly will seek only the exit he has used before, to the exclusion of all others, even though they still offer an avenue of escape.* This explains the importance of the regular means of exit and the great care that should be devoted to making certain that they will be usable at all times, especially in such structures as theaters, and the reason why the emergency exits often do not serve their intended purpose. In fact, the opinion is held by some—and, the writer believes, with considerable merit—that these so-called emergency exits, whether stairs, fire escapes, or doors, unless regularly used, are almost worthless in case of real emergency.

The effect of panic is not the same in each individual when alone. Some persons go practically mad and rush around blindly; others become helpless and cannot move. The former is the most common form of the effect of panic. The writer had an excellent opportunity of observing these phases at the burning of the Windsor Hotel in New York City (March 17, 1898). This fire, with a loss of 44 lives, took place during the middle of the afternoon. The fire department was late in responding, due to the delay in sending in the alarm. Yet after its arrival several people who were not yet in immediate danger were no longer able to stand the strain of excitement and jumped out of the windows to their death, while others who were so terror stricken that they were not even able to call for help were rescued considerably later from their rooms by firemen and taken down their ladders to the street. Another example of this form of helplessness from fright is that of a young woman factory worker who stepping out of a wash room found the workshop afire. "She stood stupified at the sight until her clothing caught fire and she received fatal burns." After the fire in the Iroquois Theater (Chicago, December 30,

* Of the ten emergency exits in the Iroquois Theater, Chicago, not cut off by the fire, only two were used during the calamity that took place on December 30, 1903, when 571 people were killed.

The report on the more recent fire in the Rialto Theater, New Haven, November 27, 1921, resulting in 9 deaths and scores of injured, states: "Panic ensued. There were exits on three sides of the building. Everyone, however, rushed to the rear."

A tenement fire (New York City, November 14, 1921) "completely cut off escape by way of the stairway, but no attempt was made to use the rear fire escape by the eleven occupants who lost their lives. This fire escape was available at all times."

1903) some members of the audience were found suffocated in the seats in the galleries. The reports state that these were the cooler headed persons who did not wish to get crushed in the jam at the exits. It is a question if this was their motive or if they were not too frightened to move and were overcome by the gases. It does not seem probable that anyone would remain seated during any such great excitement and in face of such danger. It is a common thing for people whose clothes have been ignited to rush out of the house immediately, thereby giving a draft to the flames and preventing others from rendering assistance. Where the effect on the individual is to render him immovable, his influence on his associates will not be so detrimental as when his fear takes the form of frenzy.

When many people are gathered together, any one or several may be individually frightened by fire or other occurrence and each may act according to his own impulse. But when they collectively hold a common feeling or thought they are said psychologically to form a crowd. The mere collection of people does not constitute a crowd; they may all attend a theater or lecture together, each with his own thoughts and impressions, but on the sounding of an alarm of fire they instantly have but one thought and purpose—their safety; they are then a crowd and no longer act individually but as a unit. Crowds are subject to the same emotions and to somewhat similar reactions as individuals, and what has been said about the action of fear on the individual can also be applied to the crowd. But the isolated individual when affected by emotion or impulse can up to a certain point still exercise some self-control, can consequently reflect, and therefore partly act according to his judgment, but a crowd of individuals cannot think collectively. A crowd is said to be without reasoning power. It has neither judgment nor power of reflection. When it is gripped by an emotion an impulse is immediately formed and the crowd is unconsciously driven by its instincts, which in the case of panic are to get away from the fire or supposed fire. Once the feeling of fear is aroused, panic takes hold of a crowd more quickly than an individual. Furthermore, the crowd acts on suggestion. No real danger is necessary to cause panic. Merely the suggestion of danger is sufficient if it implants a strong enough fear.* The crowd does not investigate whether or not there is true cause for the alarm, or whether there is any flame back of a puff of smoke; it does not stop to think, for as just stated it has not the power to do so. It acts impulsively and acts at once. It rushes blindly toward the exit through which it entered.

The occurrence of panic in a crowd is purely a matter of circumstance. How differently the same class of people will act under similar conditions but under different suggestion was illustrated in the fire on November 22, 1919, in Ville Platte, La. Two separate groups of people were in the same building at the same time; a motion picture was being shown in the theater on the ground floor and a dance was in progress on

---

*** When a film was being displayed in the Cannonsburg, Pa., Opera House, August 27, 1911, it broke, allowing the full illumination from the arc to be projected against the screen. A boy shouted "Fire!" and started for the narrow exit. In a moment there was a fighting, struggling mass after him. A terrible panic resulted, causing the loss of 26 lives. There had been no fire at all.**

the floor above. The fire started in a store adjoining. "Remembering that his mother was in the picture theater next door, a boy went to fetch her, and found smoke already coming through the partition wall. The people in the theater were advised to leave quietly, and all of them escaped. In the meantime the fire, working its way up inside the partition wall, burned through the floor of the dance hall about in the middle of the building." At once there was a rush for the only exit, and twenty-five of the panic-stricken dancers perished in the jam on the stairway.*

A few excited people within a gathering may by their actions transmit the same fear to the others through suggestion and in that way create a panic, for the feeling of fear is reciprocal and in a crowd is therefore self-intensifying. Like a conflagration it creates its own draft.

A crowd in the hands of capable leaders may be quickly swayed from one emotion to another. There are plenty of instances in history where the spirit of the mob has been changed from one extreme to another, as from brutality to compassion. But a crowd once thoroughly gripped by panic differs from all others in that it has no leaders and that the feeling by which it is held is so strong that it cannot be converted or changed. If, however, the fear is not immediately so intense as to reach the stage of panic, then the crowd can be swayed. If at the first suggestion of fear, when there is still a feeling of doubt, confidence can be restored by suggestion in the same manner as fear was produced, panic may be averted. The leaders of a fire drill or the manager and employees of a theater by staying resolute and making their confidence both seen and heard may transmit it to the crowd. But panic once well established cannot be checked. It dies out either through physical exhaustion or the crowd dispersing.

An individual within a fear-stricken crowd can retain his self-control only temporarily, for it is said that for some psychological reason not clearly understood the spirit of a crowd is contagious to those within it. Though one or several isolated individuals of calm temperament, who realize the value of the fire-resistive qualities of the building and its extinguishing equipment, may not entertain any fear for their safety from the fire, on finding themselves in the crowd they will have ample cause for fear from the violent actions of the mob and will soon themselves become a part of it. A few on the edge of the crowd may become separate from it and become rational again, and as individuals they may have a partial return of their reasoning powers which may permit them to look about and reach other exits if still available. But those in the midst of the crowd are both physically and mentally unable to resist the mass. They reach safety with it or succumb with it.

The impression is quite general that the tendency to panic is related to intelligence and that it is greater in those of lower mental development. Such is not the case, for as already explained panic is the result of emotional strain and therefore dependent upon the emotion stability of the individual, not upon his intelligence. This was demonstrated in the Rialto Theater fire at New Haven (November 27, 1921). The audience was composed chiefly of students of Yale University. Taken collectively,

---

* N. F. P. A. QUARTERLY, Vol. 13, No. 3, page 285.

their intelligence was probably above the average, yet a panic quickly broke out resulting fatally to several persons. Though there may be great differences in the degree of intelligence of several individuals or groups of individuals, their emotions and passions once aroused are much the same. In a panic the governing force will affect the eminent scientist and street sweeper alike, for the instinct of self-preservation is equally dominant in both.

While panic is the result of a psychological action based on fear and therefore a so-called mental condition, there is a close relationship between physical strength and mental stability; hence women and children are more liable to panic than men, and this should not be forgotten when providing for their protection against fire. Any person, though ordinarily of calm disposition, is more easily upset when sick, that is, more sensitive to emotional strains, and in proportion to his physically weakened condition. In buildings housing subnormal persons special precautions should be taken to avoid panics by providing a sufficient number of trained attendants in order that their wards can be held under control until they have been removed from the building.

The person least subject to panic is the one of orderly trained mind, like the soldier, who is accustomed to obey even when conscious of danger, and to a lesser but still appreciable degree the person trained in fire drill. In such persons the habit of obedience to their leaders has been formed. They have become accustomed to take their designated places on the sounding of the alarm and obey orders given without knowing whether or not the drill is for practice. They will do the same in case of actual fire, and having often heard the alarm signals before without disastrous results, they no longer associate them with danger but rather with the drill which to them does not mean fire but the stopping of work. By reason of this combination, together with their previous acquaintance with the various exits and their successful use of them, a sense of security is subconsciously established, which counteracts the feeling of fear and retards the rate at which it would ordinarily increase. This action, though not preventing the possibility of panic, will usually delay its occurrence sufficiently long to effect the same removal of the people from the building. All persons disciplined in fire drill, irrespective of their intelligence, are less likely to become uncontrollable as long as their leaders remain calm. The latter if well schooled and familiar with all the exits should be able to resist the effects of fear considerably longer than the untrained person. The efficiency of the fire drill is therefore largely dependent on the control that the leaders exert over their followers. This influence will, of course, be strongest when the same group of people have been continuously trained together, and accounts for the effectiveness of fire drills in schools and factories, and buildings frequented by the same people. But even in theaters and stores, if the employees, who form but a small portion of the total number of people in the building, are thoroughly trained, they can exercise a valuable effect in allaying the sudden fears of the crowd, and as long as they can keep order will prevent panic. *The value of the fire drill comes from its diminishing the probability of panic and substituting order for confusion,*

*thereby permitting the more rapid emptying of the building.**

Impressions previously made in the minds of people through their own experience or by hearing that of others have considerable influence on their liability to panic. For instance, not so many years ago when fatal theater fires were more frequent than now, there was always a feeling of danger to many who entered these buildings, and the mere sounding of the alarm of fire immediately aroused the greatest uneasiness and sometimes panic itself. This thought is no longer so prominent in people's minds. They realize the value of present methods of construction, and they see about them in the extinguishing apparatus and in the exit signs precautions for their safety. In fact, it is a question whether the greater value of the emergency exits in many theaters is not in their effect on the minds of the audience rather than being of any real service in case of fire. *If the confidence of the public can be established in the safety of the construction of the buildings it frequents, the fear of disastrous results from fire will be reduced and the likelihood of panic greatly lessened.* There have recently been fires in several new and modern theaters without any indication of panic on the part of the audience, a condition which would not have existed twenty-five years ago. On July 3, 1922, fire broke out on the stage of Grauman's Theatre, Los Angeles, a building of superior construction. The blaze was in view of an audience of 500 persons, who left the building in an orderly manner.

The fear that may terminate in panic is generally, though not necessarily, produced by what people see or hear, such as the fire itself or the sounding of the alarm, but it may also be caused by what they do not see. In the latter case, the fear is a form of anxiety caused by the suspense of not being able to verify what the person thinks or suspects is happening elsewhere in the building, and which he supposes is jeopardizing his safety. Such a mental state will develop a strain which can be sustained only for a limited time without producing panic. This strain can be relieved only by furnishing visible proof of the absence of danger, which can usually be done only by getting the people out of the building. A situation of this sort is created when people are confined too long in a stair or other enclosure even though ample protection is afforded by such construction. In other words, the sense of danger once having been aroused, people can be kept only temporarily in a confined space, regardless of their safety. They cannot be expected to remain stationary in an enclosure, but must soon move toward the final exit and must leave the building within a reasonable time if excess fear is not to be produced,

* In the $1,500,000 fire at the works of the Edison Phonograph Company, "all of the 5500 employees escaped safely, having left the building promptly and in an orderly manner when the fire drill signal was sounded." (December 9, 1914.) From report by N. F. P. A. and National Board of Fire Underwriters.

Nine hundred children from five to eleven years of age were in a three-story wooden school in South Manchester, Conn., when fire broke out (October 23, 1913). The building was totally destroyed. No lives were lost due to the fact that the children had been so well drilled that the school was emptied in 58 seconds after the discovery of the fire.

While night school was in session a fire started in the Mission High School, San Francisco, and destroyed a large section of the building (January 19, 1922). By reason of previous fire drills about 1000 students and 40 teachers left the building without injury.

which will cause them to substitute for orderly progress a mad rush which always results in many injuries.

The consequences of panic in a crowd are always disastrous, irrespective of whether the conditions causing it are dangerous or not. In their uncontrollable efforts to escape, the stronger crush and trample on the weaker. They fall into an entangled mass which blocks further progress in the passageways, and many become so maimed that they are suffocated or burned by the approaching flames before they are able to extricate themselves or leave the building.* It would appear from the records of fires involving heavy life losses that more people are killed in the panic than by the fire itself, and in some cases panic is responsible for all of the fatalities.** Therefore, in addition to providing adequate exits in theaters and other places where large numbers of people assemble, every precaution should be taken that will tend to avoid the creation of panic.

Types of Exits.

Much of the danger to life is from the spread of smoke and gases which the fire produces. These often reach the individual before he is even aware that the building is afire. Hence the planning of the interior of buildings to prevent the accumulation of the products of combustion is almost equal in importance to the design of the exits.***

No amount of fire escapes or emergency exits can altogether offset defective construction or the effects of slovenly housekeeping, and this makeshift method of giving apparent safety is too customary in this country. If a building is recognized as unsafe, the conditions within the building should be rectified. The fallacy of covering the exterior of such a building with outside fire escapes of questionable value will be revealed when the test takes place.

Every part of a building occupied by more than a few people should have at least two separate exits, on the assumption that any one way out might be blocked by smoke or flame. In larger structures those in charge should be compelled to realize that the various exit facilities have been installed to serve a definite purpose and that they should at all times be available for that purpose. A locked or obstructed door or stair is worse than none at all, for valuable time and energy may be wasted in trying to use what was believed to be an avenue of escape, perhaps making it

---

* Probably the greatest catastrophe of this kind within a century was the destruction of a church in Santiago, Chile (December 1883), in which during a panic and fire 2000 people were killed and only about half as many saved.

** The decorations ignited in a church in Pisa, Italy (1898). A panic ensued in which 12 people are said to have been crushed to death and 20 injured. There is no record of any of them having been burned by the fire.

*** "The open elevator shaft, dumb waiter, and stairways provided flues through which the fire rapidly passed to the upper floors where it ate through the thin wooden partitions into the rooms. Many of the occupants had their first warning when awakened by the suffocating smoke and roar of the flames. The hallways were already impassable and the only avenue of escape was by means of the windows. Four people, a man and wife, baby and maid, were all suffocated in one apartment before they could get outside their rooms." Melvin Apartment House fire, Boston, April 14, 1914. From report by N. F. P. A.

too late to use other exits which if they had been tried first would have led to safety. Unfortunately the person who is so indifferent to the safety of those for whom he is responsible as to permit such a condition to exist is usually equally unconcerned in the upkeep of the premises in his charge, so that these two conditions are sometimes found together, the latter intensifying the danger from the former.*

The kind of exits to be used is not so much dependent upon the construction of the building as upon the type of people who occupy it. What might insure ample safety to the operatives of a machine shop would not answer the purpose in a home for the aged. The exit facilities for each class of occupancy should be designed with a view to providing safe egress for *all* the persons of every kind who may be expected to be found within such occupancy, and with special reference to the physical and mental limitations of those persons. *Any expediency which has saved a human life has served a useful purpose, but the fact that a device has saved a life in one place is no indication that it should be recommended promiscuously in all locations, nor that it is reliable in any place.* Some hotels still provide ropes in their rooms. In the absence of other means of egress they may prove effective in those rooms which happen to be occupied by acrobats, and their use is just so much better than nothing at all, but they can hardly be termed a means of safe escape. Many lives have been saved by the inclined ladder fire escapes that are so universally used in the United States, yet they are notoriously deficient as a reliable means of egress.

The principal means of egress now in use are:

1. Openings in walls.
2. Stairs.
3. Ramps.
4. Elevators.

Any of these may be good or bad depending upon their design. The first classification includes the ordinary doors through which people pass to the street from the ground floor of a building, as well as openings in any story connecting sections of the same or two separate buildings. The latter are known as horizontal exits; and because of their simplicity, the speed with which they can be used, and the protection which is afforded by a well-constructed partition or fire wall, they are the best type of exit for giving admission to places of temporary safety.

In buildings of two or more stories in height the stairway is the

---

* According to the verdict of the coroner's jury, a locked trap door on the stairway between the third and fourth floors was responsible for the total loss of life in the fire in the Diamond Candy Company building in Brooklyn, November 6, 1915. There were two stairways, one of which was enclosed. In it thousands of paper boxes had been stored and it was here that the fire started. Consequently, this means of exit was cut off. On the other stairway was the bolted door. "The evidence is fairly conclusive that the employees worked for several minutes in an endeavor to force open the bolted trap door, but failed." The third possible means of egress, the iron exterior fire escape, was by this time no longer available on account of being crowded due to its small size and the failure of the balanced stair to drop to the street because it had caught on an open door that swung outward beyond the walls of the first story. Twelve lives were lost.

ultimate means of travel from the upper floors. It is the foundation of all systems of egress. From childhood the people of all civilized countries are accustomed to walking on stairs. No special instruction is needed, and there is no mechanism to get out of order. They are always ready for service provided smoke and flame cannot reach them. Their value lies in the fact that they can be used in the excitement of an emergency without any conscious mental processes. Travel on stairs is therefore mechanical as long as the size of the steps taken is approximately that which is usual, and the design and material used insure a good foothold. Stairs are built according to all sorts of designs and of almost unlimited kinds of materials. They vary from the stair of normal angle of rise, built of non-flammable material, enclosed in fire-resisting walls, entry to which can only be made through an outside ventilated vestibule, to the flimsy, steep inclined ladder, supported by open grated narrow balconies, attached to the outside walls of a building, access to which is had by climbing through window openings. The former is known as the smoke-proof or Philadelphia tower because it was first introduced in the Quaker City; the latter is called a fire escape, because the fire does escape from the windows and roasts the people descending from the floors above. A subsequent chapter deals with the capacity and design of stairs.

Stairs may be placed either inside or outside of a building. Apparently any contrivance attached to the exterior of a building for the purpose of allowing the occupants to leave the structure is called a fire escape. It seems to make no difference whether it is a well-built stair, an ordinary ladder, or a rope; all go by the same name. They have here been included under the heading of stairs because the only exterior facility worthy of recognition, if many people are to be removed, is the stair. However, what in this country has become popularly known as a fire escape is that arrangement of outside inclined metal steps or ladders of single width connecting a balcony on each floor but generally not terminating on the ground. It has come into such general and increasing use that it is deserving of thought and comment.

The fire escape is an economic problem rather than an engineering one. Its use is justifiable in a limited field, but the indiscriminate use to which it has been put cannot be too strongly condemned. What is to be done with the thousands of buildings already erected which while not dangerous enough to warrant extensive structural alterations are nevertheless in need of additional exit facilities to make them more safe? What is to be done to the many small buildings such as residences or boarding houses in which it is almost impossible to install another stairway to the attic so as to have two means of egress? Would not a fire escape to these rooms, which are rarely occupied by more than two or three people, be the best mode of egress that could be given these few people without prohibitive cost? In many of our cities there are two and three-story brick buildings, often on corners, used for commercial purposes, offices, sales rooms, and the like, in which there may not be a dozen people on an upper floor. Would not their safety be reasonably assured by the erection of a fire escape in addition to the enclosure of the one or two stairs already in the building? How far to go, how much to spend for changes to the building, how much for new equipment,—in other words,

what degree of protection is necessary to make a building reasonably safe in case of fire? Often this is not an easy question to answer.

For the purpose of further discussing the fire escape, all buildings will be here separated into two groups,—low buildings (not exceeding four stories in height) having a small number of occupants on the upper floors; and large and high buildings, the latter classification to include all schools, institutional buildings, and hotels, if over two stories in height. What has preceded indicates that in the opinion of the writer there are many cases where the use of fire escapes is justified on buildings in the first group, but when these buildings are over three stories the line of demarcation of where fire escapes ought to be permitted should be reached with conservative judgment. But there is no difficulty in drawing the line with respect to their use on buildings in the second group, regardless of their construction or age. *On buildings housing many people, or over four stories in height, the installation of fire escapes is absolutely inexcusable.* The subsequent statements apply to their use on such buildings. The idea of escaping from a burning building by descending on the outside is of course an old one. The fire escape is but an intermediate stage in the development of the vertical ladder to the outside stair and in common with these it has the fundamental fault of being rendered useless by flames issuing from adjacent window openings. The vertical ladder is no longer much in evidence, but this certainly seems to be the age of the fire escape. Notwithstanding that it has so often failed to perform the functions for which it is intended, its use continues unabated. Of its numerous deficiencies as a means of egress the more prominent are:

1. The danger of the people being burnt to death by flames issuing from windows below, or the fire escape being destroyed by the fire.
2. Liability of being rendered impassable on account of the obstructions frequently placed on them.
3. Small capacity because of their narrowness and because their steep pitch makes descent on them necessarily slow. The frequent absence and at other times the failure of the drop ladder from the lowest balcony to the street to operate, further add to their overcrowding, thereby delaying those within the building access to the fire escape.
4. The open spaces between steps and between bars of balconies, the low height of railings, and their steepness make their use difficult by people unaccustomed to travel on them. Many people cannot climb out of a window onto an overhanging balcony, especially if high above the ground. They become so nervous when compelled to do so that it is not considered safe to use fire escapes when conducting fire drills, which makes descent on them still more uncertain in case of actual fire.
5. Lack of illumination at night, or the formation of ice on them, or if people are in their bare feet, so adds to the difficulty of walking on them as to at times make them worthless as a means of exit.
6. Their use is restricted entirely to able-bodied persons.

The latter defect alone is sufficient to condemn them, for one of the fundamental requirements of an approved exit is that it shall be usable "by all the persons of every kind who may be found within such occupancy." An outside fire escape would therefore certainly not qualify on a hotel or on a school, a factory, or hospital. Yet they can be found on such buildings all over the country, and when so found they are proof of the ignorance or guilt of the local officials. The only brief in their favor is their cheapness and that they save rentable space. Their use is a

gamble of dollars saved against lives risked. They are a blemish on any good piece of architecture. *A fire escape on the outside of a building is an admission of the insufficiency of the exits on the inside.* It never counterbalances such insufficiency and rarely affords much additional protection to those within the building.

Here is a list of fires showing how the fire escapes may be responsible for loss of life:

Newark, N. J., November 26, 1910. Factory. Old four-story brick and joist constructed building. Smoke and fumes prevented the use of the stairway. Two fire escapes. One was located right in front of windows, out of which flames and smoke were pouring. At the start of the fire it became red hot and could not be used. On the other fire escape the bottom ladder failed to work through the sticking of a joint or ladder not being properly hooked on, so that it could not be lowered and was practically worthless as a means of egress. Twenty-five women lost their lives.

Binghamton, N. Y., July 22, 1913. Binghamton Clothing Company. Four-story brick building with wood floors; open stairways. One outside iron fire escape. Loss of life confined to fourth floor. Escape by the stairways cut off by the fire. "Girls partly down the stairs rushed back to the fourth floor. At the windows they found smoke belching out of the openings below them. Those on the fire escape were enveloped in it. With sickening speed the flames followed, and those who had not jumped to their death were burned in the building or grilled on the fire escape." Thirty-five lives lost.

Boston, Mass., April 14, 1914. Melvin Apartment House. "The stairways of the fire escapes were made impassable by the flames coming out of the windows, so that several people were marooned on the balconies awaiting rescue by the firemen." Eight lives lost.

Brooklyn, N. Y., November 6, 1915. Factory building. Two stairways and one fire escape. One stairway cut off by fire; other by locked trap door. Fire escape was then the only means of exit, and it had become overcrowded so that several jumped off it. "Its balanced stair had caught on a door which swung out beyond the walls in the first story, and for some minutes this means of escape was blocked." Twelve dead; 38 injured.

New Haven, Conn., November 27, 1921. Rialto Theater. "One of the balcony fire escapes passed a window on the first floor and when the flames broke out of this window no one could pass down. Two people were found dead on a fire escape."

However, the fire escape can be developed into a useful means of egress in the form of a stairway of customary pitch on the outside of a building. To be of acceptable design it should be continuous to the ground, and should be placed adjoining a blank wall, or shielded from adjacent windows (unless the latter are of wired glass in metal frames and equipped with self-closing devices); otherwise all the advantages that the outside stair has over the ordinary fire escape are lost. For in the latter event it is equally liable to the probability of being rendered useless by smoke and flame.*

Ramps are inclines used in place of stairs for the purpose of connecting two different levels in a building. When not too steep and when so enclosed as to exclude flame and smoke, they are as reliable as stairs. They are better where crowds are so dense that it is difficult for the individual to watch his step, as in theater lobbies or in railroad terminals where a crowd is likely to be in a hurry. Their moderate grade facilitates

* For a detailed specification for such stairs see "Outside Stairs as Fire Exits," published by the National Fire Protection Association in 1916.

the transportation of patients on litters and makes it possible for beds to be wheeled on them, a material advantage over stairs in hospitals. The reason for their less frequent use is that they occupy more space than stairways.

Recognition of elevators as a means of exit has been the subject of considerable discussion and differences of opinion. There is no argument on the point that unless elevators are in properly constructed enclosed shafts they have no merit as an exit. In fact, as already indicated, when elevators are in open shafts the latter contribute to quick spread of smoke and fire through a building. The objection raised against accepting elevators as one of the means for removal of people from burning buildings is on the grounds of the uncertainty of their being in service in case of emergency. They may be put out of commission by smoke entering the shaft, shutting off of power by the fire or those endeavoring to extinguish it, operators leaving their posts, or the elevator machinery being out of order at the time of the fire; or they may be inaccessible on the floor afire. The small capacity of the usual elevator equipment also restricts their usefulness, especially when it is remembered that all persons are presumed to be out of the burning building in quite a short time. However, the reliability of elevator apparatus has been so much improved in recent years that it would appear justifiable to place dependence on them for the removal of some of the occupants of those classes of buildings in which the major portion of the occupants is ordinarily transported by the elevators, but only when there are at least three elevators in the building and where in buildings containing over five elevators they are placed in separate shafts not exceeding four in each battery. Those not in standard enclosed shafts vented at the roof do not merit any consideration whatever as a mode of egress. An elevator enclosed but adjoining an open stair should not receive recognition on account of the danger of the elevator being rendered inaccessible by reason of the corridor filling with smoke coming up the open stairs. That elevators in well-built enclosures can be of very considerable value, both in taking people from the building and in aiding fire extinguishing operations, was proved by the fire in the fifteen-story Burlington Building (Chicago, March 15, 1922) in which the elevators remained in continuous operation notwithstanding that the contents of the upper floors were entirely destroyed.

Units of Egress.

It is not the purpose of this article to write a detailed specification on safe exits for different classes of buildings nor to describe the various dangers to which human life is subjected in these structures; but to present and explain the factors upon which the requirements of those portions of building codes which deal with safeguarding life from fire are founded, in order to aid those who may have occasion to draft such regulations or study this subject.

To make provision for sufficient means of egress from a burning building it is necessary to decide upon the time in which safety demands the building be vacated and the capacity of the exits, which will empty the building within the predetermined time, at the assumed rate of travel, due allowance being made for a proportion of the exits that might be

rendered unusable by the fire. What forms of construction and what devices may be considered reliable as exits in case of emergency must also be decided upon.

The calculations for the number and size of exits and their design, though of an engineering nature, are not founded on any exact science but are based on theory, the latter being developed from tests of emptying buildings, conducting fire drills, experience in the spread of fire, and a knowledge of what has taken place in previous fatal fires.

These have resulted in assuming certain units for the computations and in making certain deductions, the accuracy of which has not yet been proved by sufficient application nor by experience under actual fire conditions. In view of these circumstances the most recent requirements for safeguarding life from fire and more particularly those relating to means of egress, while a decided improvement over those in use prior to five or ten years ago, should still be considered tentative and progressive and should not yet be accepted as being beyond correction or further development.

The Time Element.

Time is the essence of escaping from any burning structure. All exit calculations are based on the element of time. In any building the number and size of exits required are dependent upon the time allotted for the occupants to pass through them; or, a building having a certain number of means of egress of known capacities, the number of persons that can pass through them in the number of minutes fixed as safe to vacate the building can be immediately determined, and thus the number of occupants that the building can safely house is established. The time assigned to empty a building is considered to start when the alarm is first sounded upon the discovery of fire, usually by someone yelling, "Fire!" and ends when the last person leaves the building. The beginning of the time factor being dependent upon the discovery of the fire and not upon the moment of ignition, because the latter can seldom be determined, is therefore contingent upon the interval between these two occurrences, a very variable quantity. As all exit calculations are based upon assuming some fixed length of time to vacate the premises, the start of which is entirely a matter of chance, the whole subject of exits is made an indefinite proposition which, on account of being founded on so many theoretical assumptions, makes it advisable that exit computations be made with a liberal allowance on the side of safety. Any device which reduces the elapsed time between the start and detection of fires is a material aid to safeguarding property and life. Certain thermostatic and sprinkler alarms and particularly those which automatically summon the public fire department are very valuable for this purpose.

The time factor is purely an arbitrary one based on engineering judgment. The value to be assigned to it is dependent upon many conditions, among them being the height, size, and type of construction of the building, the inflammability of its contents, the degree of hazard of the processes carried on within it, the design of its exits, and the class of its occupants,—whether children, adults, invalids, or prisoners.

Three minutes is the most generally used figure to empty a building. It is too large for the very hazardous occupancies, whereas five and even

ten minutes have been suggested for well-planned fire-resistive buildings wherein the contents are not highly inflammable and in which all stairs and inside vertical openings are well protected.* In fact, buildings over twelve to fifteen stories in height cannot be emptied in less than five minutes. It should be possible to empty all theaters and places where the public assembles in large numbers in three minutes, not only on account of the danger from the fire itself but because of the liability of panic and the resultant casualties therefrom.

In schools and institutional buildings of the best grade of construction, in which fire drills are frequently held, the buildings should be vacated in not over four minutes. Where these buildings are of wood or brick joisted construction with open stairs, they should be emptied within two minutes. Three and four-story schools housing 500 to 800 pupils have been emptied in less than two minutes after the sounding of an electric alarm. The rules of the New York City Board of Education require that "Each building shall have a sufficient number of fireproof stairways and of exits to permit of its occupants vacating same in not more than three minutes in non-fireproof and not to exceed three and one-half minutes in fireproof structures."

In 1917 and 1918 the Committee on Safety to Life of the National Fire Protection Association developed a schedule for the time of emptying factory buildings. The limits set were made dependent upon the height and construction of the building, the enclosures or lack of enclosures of the stairs, and the character of the materials stored or manufactured in it. They can be summarized as follows:

	STORIES	SECONDS
Frame and Joisted Construction without sprinkler system	2 to 7	42 to 142
Frame and Joisted Construction with sprinkler system	2 to 7	41 to 246
Mill and Fire-resistive Construction without sprinkler system	2 to 12	45 to 178
Mill and Fire-resistive Construction with sprinkler system	2 to 12	43 to 310

The height of a building permissible for factory purposes was limited by its construction and the hazard of the processes carried on within it. For example, buildings having open stairways were not permitted over five stories in height, regardless of materials of construction, and then only when the contents belonged in the least hazardous classification. In buildings containing the highest degree hazards open stairs were not allowed at all. When expert testimony was being given before the New York Factory Investigating Commission, which resulted in the present Labor Law of the State of New York, this statement was made with respect to factories, "In considering this matter with a number of persons who are able to pass on these questions and who have given it careful thought, we have all in a measure come to the conclusion that a three minute limit is approximately a reasonable time in which a building should be emptied in order to secure safety to the occupants. Now it seems to me that with the talent which the Commission has, and the experience they have had, that they should be able to provide a simple bill which would require a drill to determine whether the exits of any building are sufficient for the occupants, and if they are not sufficient, then some-

* In a film exchange fire the entire building was ablaze within three minutes. Three persons perished and several were severely injured, notwithstanding the fact that the fire occurred during the middle of the day in a two-story building.

thing must be done so that the building can be emptied within the three minute limit."

Records of the time required to empty very high buildings are scarce, and fatal fires in such structures are equally few in number, yet the possibility of their occurrence exists.* During a fire in 1920, the thirty-story Bush Terminal Office Building in New York City is said to have been vacated inside of fifteen minutes. The number of people who were in the building at the time is not known. Former Chief Guerin of the New York Fire Department has stated that "Descent can be made from a twelve-story building in three minutes" and that "between 380 and 400 operatives can walk down a stairway in a twelve-story building in five minutes." In general it can be said that five minutes will be consumed in removing the occupants of twelve-story buildings, and more for higher structures. When structures reach twenty stories in height, considerable physical exertion is required to descend from the upper floors by means of the stairs and the rate of descent becomes much slower than in lower buildings. Some engineers have advocated fixed maximum emptying times for the entire population of various classes of buildings, which if adopted would limit the height of new buildings to a moderate number of stories. But notwithstanding these gentlemen, high buildings will continue to be erected. Industry and progress cannot be retarded. Instead of limiting the height of buildings to conform to certain safety restrictions, necessity demands that engineering science provide the means to make higher structures safe in case of fire. That present methods of construction when properly applied afford ample safety even in very high structures, the writer is convinced, and that the long emptying time which is unavoidable in such buildings is justified when the vertical spread of smoke and fire is prevented, zones of safety are created, and the degree of hazard of the tenancy is properly restricted.

Safety Zones.

Zones of safety may be another fire section of the same building to which access is had through doors, or may be a stair enclosure, or any other place of refuge into which the occupants can have quick access from the room or compartment in which the fire has started, and where they may remain for a short time fully protected from heat and smoke. In the building of moderate or quick-burning construction in which flames can spread rapidly and in such structures as theaters and auditoriums, temporary protection is not sufficient, and it is imperative that upon the alarm of fire their entire populations can be immediately removed to the street within the assigned time. But in the modern fire-resistive building of many stories this procedure cannot be followed. If in the latter buildings the vertical shafts are enclosed, the spread of fire from floor to floor and from horizontal section to horizontal section will be much slower, so that considerably more time may be permitted to empty the entire building but not to reach a place affording temporary protection.

* Two men lost their lives in a fire in a modern ten-story office building in New Haven, Conn., during the afternoon of January 15, 1920. One was unable to escape from the basement; the other was suffocated on the top floor. The flames did not spread beyond the basement.

The fact that these buildings burn more slowly and resist heat longer has caused some to forget that hazardous substances and combustible materials will burn as quickly in a fire-resistive building as in any other, so that it is as important to establish a unit of time for entering safety zones as one for emptying the entire building.

The length of time to be assigned for this purpose is dependent upon the nature of the operations conducted and the inflammability of the materials stored in the premises, not upon the materials of construction of the building nor upon the number of persons within the area under consideration. Two minutes will be safe for low hazard occupancies such as office buildings, but not exceeding thirty seconds can be allowed where there is any danger of a flash fire. It must be remembered that this means the removal of only those people who are in the unit of a building in which the fire originates and where it can expand to, but not easily beyond, the enclosures of the adjoining units. The occupants of the fire area being within the safety zone, the next step is their removal from the building, as well as that of all others within it, which is a matter of emptying time as previously explained.

Places of temporary refuge are particularly essential in hospitals and institutions in which the inmates need the assistance of others to help them out of the building. Probably all the patients in a hospital ward could be carried through a fire partition to a temporarily safe place in the corridor one hundred feet away or gathered on a porch outside of the ward in the time it would take the attendants to carry one-third of them to the street. In other words, instead of taking the time to transport a few a long distance to absolute safety, thereby perhaps jeopardizing those left behind, all could first be carried a short distance to a temporarily safe place and from there start the final removal to the street.

Safety zones having been provided where necessary and the emptying time having been decided upon, the next step is to determine the number and size of the means of egress necessary so that the people within the building can leave it in the assigned number of minutes. Disregarding for the moment the type of exits to be used, their number and width will depend upon the speed with which people will pass through them and what proportion it is assumed will be rendered inaccessible or useless by the fire. It may be needless to state that every building and every fire area of any building should have not less than two ways out. Where there are more than two means of egress, it is customary to assume that one-third of their total width cannot be used. And in determining this total width of exits only those of acceptable construction are to be included, no allowance being made for unapproved types.

Rate of Travel.

Many tests have been made to determine the rate at which people leave a building. The results are far from uniform. As the consequence of these trials, most of which have been made while conducting drills in schools or factory buildings, it is customary to assume that walking in single file people will pass through a door or past a given point at the rate of 60 per minute. When making these tests, however, it is found that the rate at which the occupants leave the building is by no means

constant and that instead of coming out in a steady stream, they often come in groups with intervals between.

Assuming that the slope or pitch of the stairs or inclines differs but little from what people are normally accustomed to, the actual rate of travel of the average person through halls, doors, and exits, and the rate of descent on stairs, is dependent upon the density of the mass of people, the distance covered, the number of changes in direction of travel, and upon the collective mental state of those using the exit. While there are plenty of records of emptying times of buildings at drills, there are practically none under fire conditions, so that this important factor in exit calculations—the rate of travel—is also based on assumption.

Where people assemble in a conglomerate mass, commonly called a crowd, their density, as already stated, will affect their speed of movement. When packed so closely that there can be neither an individual or general movement, there will be one person per two square feet of space and equivalent to an average weight of 75 pounds per square foot, this being the assumption for the capacity of elevators. The non-moving crowd of usual density occupies three square feet per person, but as the mass begins to move the individual requires more space, approximately in proportion to the acceleration of his speed. When moving leisurely in one direction, a crowd occupies five square feet per person but when a speed of three miles per hour is attained each person averages about ten square feet of space. Where the movement is in two directions, as on sidewalks and in railroad terminals, more space is needed. According to a test reported by Messrs. J. Vipond Davies and J. Hollis Wells in 1909, a crowd discharges about 30 persons per minute per foot of width of opening and this rate will be maintained even though the density changes. In other words, while the thinner crowd moves more rapidly than the congested one, the number of persons passing through the exit per minute remains constant.

An individual can descend several flights of stairs of the usual story height, 10½ to 12 feet, without undue haste, at the rate of 8 to 18 seconds per floor, depending upon the design of the stairs. People, collectively, leaving a building of moderate height, take 10 to 20 seconds per story. If the number of stories descended exceeds six, the physical exertion involved will cause a slackening in speed so that between six and twelve stories the descent will take about 15 to 25 seconds per floor, and as still more stories are added the time will increase to 30 seconds per floor. These figures are for mixed occupancies of men and women of ages generally found in commercial life. As long as the time to descend one story is not greater than 15 seconds, the rate of travel past a given point, and therefore the discharge from the building, will still remain 60 per minute per unit width of exit. But if the speed of descent is lessened to 20 to 30 seconds per floor, the rate of discharge will be proportionately reduced. Except in the lowest grades, school children descend stairs at the same speed as adults but they are more quickly affected by fatigue so that they cannot keep up with their elders if more than three or four flights of stairs are to be descended in succession.

The ascent of one or two flights of stairs is not much slower than descent, but fatigue is produced so much more quickly when climbing stairs that the rate of travel is lessened rapidly as additional floors are

mounted. However, there being very few buildings with more than two floors below the ground level, the rate of 15 seconds per story can be taken for going up stairs of not more than a total height of 25 feet.

As already explained, these figures for the speed of travel on stairs are based on their being of the usual pitch, which is from 38 to 41 degrees. Any marked variations from the customary height of risers or frequent turns in direction result in a material reduction in the speed of descent. The introduction of winders or long continuous stairs without intermediate platforms has the same effect, and if excessive these cause loss of foothold, thereby throwing people and ultimately blocking further progress.

In nearly all buildings stairs constitute the principal means of egress from the upper floors, so that their design and construction should receive the closest attention, it being remembered that to make them effective in case of emergency they must possess the following characteristics: Flame and smoke must be excluded by enclosures; stairs must be of such pitch and number of successive treads that they will not create an excessive momentum or speed; their surface should be such as to assure a good foothold; they should be equipped with hand rails to afford support; and when of widths greater than necessary to accommodate two files of people, they should be provided with intermediate rails or be of such widths as to prevent blocking and the forming of human arches.*

Capacity of Exits.

There has now been given the data on the time in which persons should reach a zone of safety and in which it is safe to have buildings of various types emptied of their occupants, and also the speed with which they will leave the building. These being assumed, the number and size of the various forms of exits can be calculated.

Figures have already been given on the density of crowds, and these can be modified to permit assigning the space occupied by people in safety zones, corridors, and stair enclosures. The former can be taken at five square feet per person, and four square feet in the latter two places. Except in the larger public buildings stairs are rarely found more than five feet in width. The rate of discharge on wide stairs is not known under fire conditions, but in ordinary use in such places as railroad terminals it has been given as 13 to 18 persons per minute per foot of width. Wide stairs of the old type are objectionable from a safety standpoint when they are used under excitement and undue speed on account of the danger of the mass falling. Stairs should preferably be of such widths that those using them will be compelled to walk in files, each file having the support of a hand rail. It is particularly desirable that the total width be such that three files cannot use the stairs, as in such case the danger of jamming is much more probable. The middle person having no support, either is thrown by the pressure in back or becomes wedged between the two on the outside. In order to have some basis for calculating the capacity of stairs, it is usual to assume that while in motion

* For detailed specifications for properly designed stairs, the reader is referred to the "Building Code of the State of Wisconsin," "Building Code of the City of Cleveland," "Exits Standards of the Safety to Life Committee of the N. F. P. A.," and the chapter on Egress of the "Building Code of the National Board of Fire Underwriters."

one person will occupy every other step. On this basis, assuming an average stair height of twelve feet and sixteen steps, and taking into account the area on landings and enclosure halls, the double width enclosed stair with intermediate landing on which the direction of travel is reversed, and which on account of the comparatively small space it occupies is being most generally used in modern construction, holds 14 persons per unit of width or a total of 28. By the same method of figuring, the straight run enclosed stair holds 21 persons for each unit of width. Eighteen inches is about the width of the average adult, and in existing buildings this is the figure taken as a unit of exit width; but somewhat more room is desirable where two or more people walk abreast. In order that they may have sufficient space so as not to be retarded by being too close together, twenty-two inches is now becoming the recognized unit width for new construction in this country.

In addition to the time required to descend from upper floors to the bottom of the lowest tier of stairs, a certain time is consumed in assembling and reaching the stairs before there can be any steady flow or discharge, and a few seconds more will be spent between reaching the bottom of the last stair and the street. This assumption again must be an arbitrary one, for which 30 seconds seems to be a reasonable estimate.

Where separate exits are not provided for the exclusive use of the occupants of the ground floor, then the street exits must be of sufficient width to accommodate persons on the ground floor without retarding the progress of those descending from the upper stories. In such buildings as factories, department stores, and theaters, it is preferable to design stairs to lead directly to the street instead of terminating within the first floor area or in a common vestibule.

The capacity of an elevator car is one person per each square feet of area. The number of persons that can be transported by the elevator equipment from the upper floors to the street level within the time fixed for emptying the building depends upon the number and size of the cars and the time consumed by each in making a round trip. The latter is composed of so many varying factors, such as speed of travel, width of door openings, time of entry to and exit from car, etc., that space does not permit giving and explaining the formulas from which this data can be calculated. For such information the reader is referred to R. P. Bolton's book on Elevator Service, and to the Otis Elevator Company, New York City.

Number of Occupants.

The size of the exits will be dependent upon the number of persons to be removed, with two exits as the minimum in every building. In dwellings, tenements, factories, and theaters, the number of persons that occupy them is fixed in the first three cases by the proprietors and in the latter case by the number of seats plus an allowance of one person for each three feet of standing room; but in most other buildings there is only partial or no control over the public's use of the structure and the units must be designed to handle not the usual but the maximum number who at any time may be expected to be within such building. Hence, in office buildings, stores, hotels, and schools, the probable number of occupants must be estimated by dividing their floor area by the usual unit of allotted

space per person in the class of building under consideration. The populations of several types of even the most frequently used buildings are not known. Investigations are now under way to gain this information. The number of persons for whom exits should be provided can, until more accurate counts have been made, be based on the figures following.

PUBLIC ASSEMBLY (Auditoriums, Lecture Halls, Dance Halls). Where there are fixed seats the number of persons should be determined in the same manner as for theaters, but where movable chairs are used, there will be about six square feet per person. The actual space occupied by seats is 3½ to 4 square feet, to which allowance must be added for aisles. In halls of large size used for miscellaneous purposes of assembly, including dancing, the space occupied per person will be within the limits of 6 to 15 square feet, with 10 square feet per person as the approximate average.

THEATERS. In theaters the number of occupants is equal to the actual number of seats plus one person for each 3 square feet of space allotted to standees, it being assumed that the aisles will be kept free from obstruction.

SCHOOLS. The population of these buildings should be figured at one pupil to each 15 square feet of class room area. The latter is generally about 50% of the total floor space exclusive of, and to which should be added, the capacity of auditoriums on the same basis as places of public assembly. Gymnasiums and auditoriums can be taken at 6 square feet per person. Since night instruction has become so prevalent and as the lecture halls of schools are often open to the public, the populations of school buildings must be estimated by considering that all rooms are occupied at the same time, and not as formerly on the assumption that the class rooms will be vacant when the rooms assigned for special purposes are in use.

STORES. The maximum number of customers congregate in the larger stores only a few days during the year, but it is for such occasions that the exits must be designed. On the street floor the density will be about 25 square feet of gross area per person; on the upper floors it will be about 100 square feet, while in sales basements an area of 40 square feet per person can be assigned. In basements not used for sales purposes, this figure may be increased to 100. These figures include both customers and employees. Densities higher than those mentioned have been recorded, but they are only in exceptional cases where unusually dense crowds collect. Where restaurants or lecture halls are found in department store buildings, the capacities of these rooms must be added to the space used for sales purposes.

FACTORIES. The number of workers will depend entirely upon the nature of the manufacturing conducted on the premises, and is fixed by the owners. Where, however, an existing building is to be used as a factory, the number of occupants should be restricted to the capacity of the exits already provided, or additional ones constructed to meet the increase in number by whom the building will be used.

The areas per person in the above types of buildings have been reasonably well established by actual counts. The figures for the following classifications are not definitely known.

OFFICE BUILDINGS. The number of occupants per office varies with the class of business conducted in the building. For instance, buildings which house large corporations using large open spaces for their clerical forces have a greater density of population than those in which there is a mixed tenancy of many small private offices. As a general rule in these buildings in the larger cities there will be from 140 to 200 square feet per person of gross area of upper floors,—that is, the area within the building lines and not the rentable space. One person per 150 square feet of space is recommended as a safe figure.

LOFTS. The large open areas in modern buildings, commonly known as lofts, are used for such a variety of purposes that it is impossible to assign any unit of population area for this classification as a whole. In buildings where the lofts are divided into small sections, say from 500 to 2000 square feet each, and which are generally used as sales rooms, the conditions are approximately those found in offices, in which there may be 100 square feet per person; or the lofts may be so large and so filled with merchandise that they become practically warehouses, with one person to about each 1000 square feet. In such buildings, ample safety will be furnished the occupants through the customary requirement that there shall be at least two stairs and by limiting the area between walls.

HOTELS, APARTMENTS, AND TENEMENTS. The unit for estimating the number of persons in these public dwellings should be a function of the number of rooms and not based on the area of the building. There is a considerable range in the number of persons per room in these buildings, depending upon the class of patrons to which they cater. In the cheapest tenement houses several people often occupy each room, while in the highest grade apartment buildings the number will be found to be less than one per room. In hotels it is said to be from one to two for each rentable room, exclusive of employees. The writer is not able to furnish definite data on these buildings. In the very large hotels the lower floors often contain banquet and dance halls, which should be treated as places of public assembly, and exits provided in addition to those for the normal occupancy of the floors above.

Fire Drills.

Wherein the fundamental value of the fire drill lies has been explained under the heading of Panic. To what extent the number or total width of exits in a building might be reduced with safety by reason of the more rapid departure of the occupants is problematical. Without wishing to detract from the very considerable yet undetermined value of the fire drill, it must be acknowledged that on account of the extreme range in efficiency of drills, as they may be conducted under varying conditions and in different kinds of occupancies, it is advisable, for the present at least, to regard the fire drill as an extra or additional factor of safety instead of a substitute for a portion of the exits.

Protection of Life in Dwellings.

As stated at the beginning of this article, its purpose is an exposition of the fundamentals of protecting human life against destruction by fire. While practically all reference has been to fatalities and all examples

cited have been those of people killed, nothing has been said of the thousands who each year sustain injuries on account of fires. It is not within the province of this article to dwell on these cases, but it can be put down as a rule that for every person killed in a fire through lack of or faulty exits, several are hurt, nearly always seriously. Their injuries are generally burns. These cause intense suffering and disabilities which result in a considerable economic loss, and are worthy of preventive efforts second only to those for the preservation of life. No attempt has been made to discuss the special conditions inherent to each distinct class of occupancy, for the underlying principles are much the same for all. In the larger structures and all those housing many people, insufficient means of egress is the most frequent cause for fires terminating fatally. This statement does not apply to dwellings. Because of their usual small size and because their architectural plan is necessarily very different from other buildings, the design and requirements for exits in dwellings are also different. Furthermore, the circumstances of both the origin and spread of fire in them are not the same as in other buildings, and since the greatest portion of the total annual life loss occurs in the home, that building will now be considered as a separate type.

For the purpose of this article a dwelling may be defined as any building used solely for residential purposes and occupied by not more than two separate families. Apartment and tenement houses are not included, because, though they are residences, they often contain commercial occupancies on the ground floor, and on account of their size they introduce hazards and structural problems not found in the ordinary home.

According to the records of fatal dwelling fires collected by the author, 38% of them occur at night, and a study of this information tends to show that in only about one-half of the fires did the occupants succumb because the building had caught fire. In the other cases they had set their own clothing afire, the contents of the dwelling sometimes but not always igniting as a result. It is interesting to note what a large portion of these fires were started by children playing with matches. Of the 370 deaths tabulated, 14% were men, 21% women, and 65% were children. A summary of the causes is as follows:

Playing with matches	13.5%
Clothing igniting from stoves, open fires, or smoking	32.2%
Explosion or overturning of oil lamps or stoves (includes gasoline)	33.5%
Building afire (from all other causes)	21.8%

The majority who die in dwelling house fires lose their lives directly or indirectly through some fault of their own, either by setting themselves or the house on fire; or the house catching fire, they are unable to escape because of hazardous conditions within it which they could have removed. In other buildings those burned are more often victims of circumstances over which they had no control, they generally being employees or visitors in buildings in whose planning and management they had no voice. In the same category of deaths, namely, those due to the individual's own acts, are the losses of life caused by delaying departure from a burning building in an attempt to remove personal property, or

by entering the building for the same purpose. As these classes of fatalities cannot be charged to faulty building design or construction, this article is not concerned with them except in so far as to point out that together they constitute a very large proportion of all the deaths from fire in the home.

In order that a building may serve the purpose of a residence and that it may be an attractive place in which to live, large open spaces are necessary, especially for halls and for main stairs between floors. This style of architecture facilitates the spread of fire; its extinguishment is accordingly difficult; and the difficulty of arranging separate means of egress, particularly in the smaller residences, make the importance of good housekeeping all the more imperative. A high standard of good housekeeping should be considered a necessary and direct protection to the lives of those who reside within the building.

Safeguarding life from fire in most dwellings and in all one-story houses is therefore principally a matter of the prevention of the common fire hazards.* Fatalities in these houses are in the same class as those occurring in single rooms of larger buildings where the fire does not spread beyond the room of its origin, and are generally cases of the victims setting themselves on fire.

When the home becomes larger, having a cellar or is two stories or more in height, then in addition to the ordinary hazards created by carelessness, which are not limited to dwellings of any size, there enters the hazards of construction. The usual methods of construction of dwellings give scant consideration to fire protection. Little attempt is made to build so as to retard the progress of a fire. Most houses contain concealed spaces which allow a fire gaining access to them to eat its way without hindrance from floor to floor gaining headway without discovery until it suddenly breaks out into the open as a fire of considerable proportions. An essential element in the safeguarding of life in all dwellings is that their design be such as to retard rather than encourage the spread of fire and so far as possible to confine it to its seat of origin. Examples of such preventive measures are the enclosing of furnaces in separate rooms with plastered ceilings, subdividing attics, the fire stopping of studding at floor levels, placing doors at the head of basement stairs, and isolation of garages.

The greatest danger from bad structural conditions and the necessary presence of large open spaces and stairs is at night. When the people are asleep and the bedroom doors are closed, all the lower portions of the house may be involved in a fire before its discovery; and when discovered, it is found to fill the halls and stairs, the very places by which the occupants would seek to leave the house. If by that time the gases have not already caused suffocation, and unless there are other means of egress of such design as to exclude both smoke and fire, departure by the windows must be resorted to. Of the fatal dwelling fires of which the writer has a record, nearly all of those in which the occupants were trapped occurred at night.

---

* The common fire dangers in the home and how to avoid them are explained in Circular 75 of the United States Bureau of Standards.

Probably no better example than the following could be given to illustrate how even slight carelessness with respect to a common hazard may lead to fatal results, how easily a fire at night can consume much of the interior of a dwelling before discovery, how smoke and gases travel ahead of the fire and may cause suffocation before an exit can be reached, and how little dependence can be placed on outside aid even though near at hand. While Brigadier-General John J. Pershing was on the Mexican border, fire broke out in the two-story wooden house occupied by his family in the Presidio Military Reservation in San Francisco. The fire started about four o'clock in the morning of August 27, 1915, from live coals dropping out of an open fireplace onto the hardwood floor which was oiled and very inflammable. The hangings caught fire, and the flames soon enveloped the entire lower floor and with the smoke rushed up the open stairway in the front part of the house. Mrs. Pershing and her four children, a guest with two children, and two maids were asleep upstairs. This guest was first awakened by the fire but not until the entire lower part of the building was ablaze. With her children she rushed to the stairway, and finding it in flames, escaped by way of a window onto the roof of a porch. The alarm was then given and though soldiers nearby and firemen responded promptly, they were not able to save Mrs. Pershing and her three little girls, who perished by suffocation. The General's little boy and the others were rescued, though they received minor injuries. An army officer who was present at the fire reported that "the flames were so intense and the smoke so terrific that Mrs. Pershing was close to death, probably, by the time she awoke."

The question of exits hardly enters until the home assumes larger proportions and then the problem becomes a difficult one because the larger and more pretentious the residence the more the importance attached to architectural effect, which means large open spaces and wide open stairs. These parts of the house with their hangings of curtains and draperies furnish both fuel and draft for the rapid spread of fire and smoke; and the fact that many of such houses are built of masonry and steel will have but slight effect toward reducing the danger to the lives of the occupants, unless subdivided into separate fire areas. Their walls may not burn but their contents do with great rapidity. To make the large dwelling safe, irrespective of the materials of its construction, a definite system of exits must be provided. Their safety requirements differ little from those of apartment houses. All sleeping compartments above and below the ground floor should be provided with two separate paths of exit. This can be accomplished by dividing these floors into one or more fire sections by the construction of fire partitions * or masonry walls across the house with self-closing doors in the halls. Communicating doors between bed rooms or connecting porches outside of them will permit the occupants to have access to adjoining fire areas without entering halls of the section in which the fire is burning. Besides the main stairway in the central section, there should be a stairway in each of the other sections, it being remembered that the latter stairs are installed for emergency purposes as well as for convenience, and unless

* Metal lath and plaster, gypsum or terra cotta blocks.

they are properly designed they may have little value in case of fire. Though preferable, it is not necessary that they be built in separate enclosures of their own as in commercial buildings, provided the hallways in which they are located are not unduly large and are separated from other corridors by doors. The back stairs as built in so many houses cannot be considered to be an acceptable exit unless they are separated from front halls and unless they are independent of the stairs leading to the cellar. No stair should terminate in a kitchen or in a room containing a furnace.

In many dwellings already built it is practically impossible to change the construction to conform to the above requirements. In these, dependence must be placed upon the more hazardous means of departure through the windows. It may be by exterior stairs, fire escapes, rope ladders, or patented rope or wire lowering devices. These sometimes answer the purpose where only a few persons are to be taken to safety, but are all subject to the objection of being rendered useless by flames issuing from lower story windows. Any contrivance for escaping from the windows should be permanently attached to them, and the reliance for rescue that by some is placed on the ladders that the fire department is expected to raise should be totally disregarded. It should be remembered that when the fire is discovered in its early stages the exits are rarely cut off, but if the fire has reached such proportions that the usual means of egress are blocked upon its discovery, then by the time the fire apparatus is on the scene those in danger will usually have succumbed or be so panic-stricken as to jump out of the windows.* Access to the roof as a temporary place of refuge is always desirable. A stair or inclined ladder to the roof should be in place at all times, and the scuttle should be secured in a simple manner so that it may be opened without delay even under stress of excitement.

In the older eastern cities of the United States there are innumerable rows of three, four, or five-story brick houses without any open space between buildings which generally have party walls and in which there is but one stairway in each. Of all types of dwellings they are the most dangerous. After a fire gains any headway in such a building, practically all opportunity for escape is contingent upon the prompt arrival of the city fire department. If a back stairway with a door between front and back halls cannot be built in these houses, then outside metal stairs should be installed on the rear wall, or balconies placed at floor levels connecting each two adjoining buildings.

In the planning of the home, avenues of escape in case of fire should not be omitted nor the building of fire stops neglected; but good construction cannot offset the effects of bad housekeeping or personal carelessness.

---

* The owner of a particularly fine five-story brick house with brownstone front in New York City, realizing the danger of fire in his home notwithstanding the excellence of its construction, negotiated with his adjoining neighbor to cut a connecting doorway between the two houses. Before it was done a fire broke out at night, and even though at the time two companies were in fire headquarters only three blocks away, the owner of the house and two others died in the fire. (Andrews fire, 2 E. 67th St., New York City.)

Conclusions.

The waste of human life through death by fire and the suffering from burns are unnecessarily great in the United States.

The heaviest loss is in the home.

More than three-quarters of all who perish each year are women and children.

A large proportion of those who are burnt to death first ignite their clothing, it in turn setting fire to the building.

In burning buildings, most of the victims are first overcome by smoke or gases and then are burnt to death, but the fire often destroys the evidence.

There are few fires in which more than five lives are lost, but those in which one or two are sacrificed are of such frequent occurrence that they often pass unnoticed.

In fires which result in many deaths panic is the greatest contributing factor.

As in the origin of all other fires, so in those resulting fatally, carelessness is the outstanding cause.

Greater effort and more progress have been made in the protection of property from fire than in the protection of human life.

Of the larger buildings, those which have received the greatest attention in respect to safeguarding life are the buildings which people enter of their own free will and accord. But in those buildings in which attendance is compulsory, as schools, and in those in which people are confined and where the inmates have neither a voice as to the conditions within the building nor any choice concerning their residing therein (as hospitals, orphan asylums, jails, and other institutional buildings), construction, upkeep, and means of egress have been and still are inexcusably bad.

It is of primary importance that the normally used exits be so constructed that they in preference to all others will be usable on the outbreak of fire.

A well-enclosed stair shaft not only assures safety to those leaving a burning building through it, but also gives access to the upper floors to firemen and a safe point of vantage for them to attack the fire.

The fire escape has proved to be a failure as a trustworthy means of egress on buildings of four stories or more in height and on all structures where large numbers of people assemble.

The present unfortunate conditions responsible for the too frequent fatalities in fires are due chiefly to the character of the American people with their indifference to the value of human life. The correction of these conditions will be a gradual one which can only be accomplished by education with the assistance of engineering. To be effective, this education must be accompanied by suitable penalties for those who are wilfully negligent. It must be national in scope, and should be undertaken by the government or by a national organization having government support.

Heating Elevated Steel Sprinkler Tanks.

By C. D. Abbott, Assistant Engineer.
Factory Mutual Laboratories.
(Member N. F. P. A.)

Heat losses from steel sprinkler tanks and the performances of steam heated water circulating tank heaters have been determined by the tests described in this article.* From the data obtained, the curves and tables at the end of this report have been prepared, giving heat losses, and recommended sizes of acceptable heaters for tanks of various sizes. Further tests are desirable to include heat losses from steel tanks of different shapes and sizes, and wooden tanks, and to study the performances and efficiencies of various types of heaters.

Appreciation is expressed for assistance rendered by the Quincy Cold Storage Co., the Gillette Safety Razor Co., The United Lace & Braid Co., The Factory Insurance Association and the Grinnell Company, Inc., each of whom was instrumental in making it possible to conduct the tests.

Description of Apparatus.

In both tests, the essential details of the apparatus were as follows:

SPRINKLER TANKS. The hemispherical bottom steel tank at the Gillette Safety Razor Co. had a capacity of 50,000 gallons, and was elevated 34 feet above the roof of the building, or approximately 155 feet above the ground.

The steel tank at the United Lace & Braid Co. was of similar size and shape, and was located on an independent tower elevating the bottom 75 feet above the ground.

HEATING SYSTEMS. A No. 4 tank heater manufactured by the General Fire Extinguisher Co. was used. This heater consists of a cylindrical cast iron shell containing a brass steam coil. The heated water rises through the hot water pipe to discharge at approximately the center of the tank from which point it circulates about the tank, and finally returns to the heater through the tank discharge pipe.

The 2 in. hot water pipe and 8 in. tank discharge were enclosed in a three ply two air space wooden frostproof casing. The heater and connections were not covered with insulating material.

The circulating pipes at the Gillette Safety Razor Co. had been in use for three years, while those at the United Lace & Braid Co. were five years old. It is probable that the amount of scale, corrosion, or sediment, tending to restrict circulation was not more than average.

TEST INSTRUMENTS. A steam separator and a recording steam pressure gauge were installed in the steam supply pipe near the heater. The return was equipped with a steam trap which discharged the condensation into a barrel arranged to empty automatically through a meter which

* Tests conducted during winters 1917-1918, 1920-1921, 1921-1922.

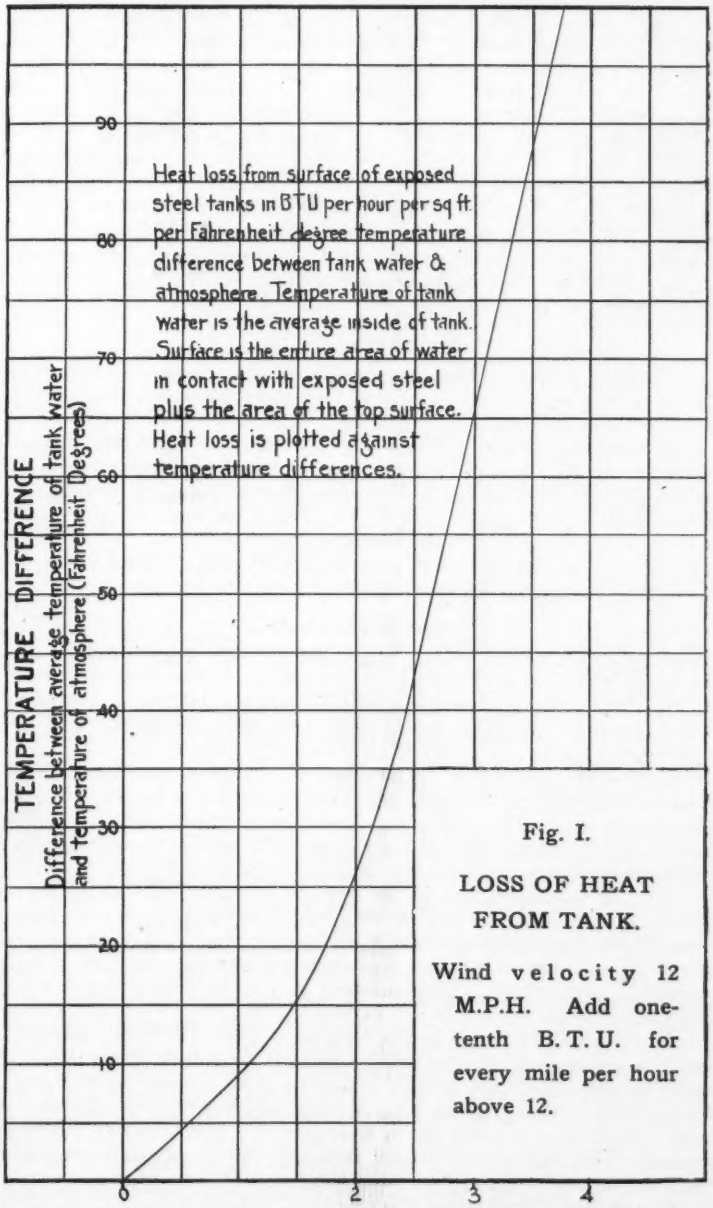

Heat loss from surface of exposed steel tanks in B T U per hour per sq ft per Fahrenheit degree temperature difference between tank water & atmosphere. Temperature of tank water is the average inside of tank. Surface is the entire area of water in contact with exposed steel plus the area of the top surface. Heat loss is plotted against temperature differences.
TEMPERATURE DIFFERENCE
Difference between average temperature of tank water and temperature of atmosphere (Fahrenheit Degrees)
90
80
70
60
50
40
30
20
10
0
2
3
4

Fig. I.

LOSS OF HEAT FROM TANK.

Wind velocity 12 M.P.H. Add one-tenth B. T. U. for every mile per hour above 12.

Heat Loss.—B.T.U.'s per hour per sq. ft. per Fahr. degree temp. difference.

registered the amount in gallons. Mercury thermometers were installed in the steam supply, steam return, cold water return, and in the hot water pipe near the heater. A recording thermometer with bulb inserted in the cold water return was also provided. Atmospheric temperatures were registered by an aneroid recording thermometer located on the north side of the tank balcony. A recording thermometer with bulb at about one-half the depth of the water was installed inside the tank to obtain the general variation of temperatures that occurred between the readings of five mercury thermometers which were inserted in bottles of water and located, one in the settling basin about 6 in. above the extreme bottom, one 6 in. above the settling basin, or 2 ft. above the bottom, one at the plane between the cylindrical and hemispherical portions of the tank, one at the surface of the water, and one at the discharge of the hot water pipe.

Procedure of the Tests.

During the tests, readings were taken of the condensed water meter, the steam gauge, and each of the various thermometers daily, except Sundays and holidays.

The steam pressure at the heater was changed from time to time to obtain the relation between pressure and amount of condensation. During certain periods, the steam was entirely shut off, and daily temperature readings of the tank water and atmosphere were taken to determine the relation between the temperature difference and heat loss.

Data obtained has been assembled and computations made from which the deductions contained in this report have been drawn.

General Observations.

In addition to the major observations other features were noted, which are discussed as follows:

1. Water in the settling basin is most sensitive to atmospheric changes, and generally during freezing weather the coldest water in the equipment is at 39° F. to 40° F. in the settling basin and blow-off pipe above the valve. There is danger that the water or sludge at the latter point may become trapped and freeze locally, and it is accordingly important that the top of the frost casing should be connected tightly to the tank bottom, and that the hot water pipe should be placed as near as possible to the blow-off pipe and not surrounded with insulating material.

2. The warmest water in the tank, except that at the hot water pipe discharge, is at the surface. The variation between the surface and bottom is not uniform, it being materially less between the top and bottom of the cylindrical portion of the tank than between the top and bottom of the hemispherical portions. Temperatures in one horizontal plane are approximately constant.

3. The coldest water in the circulating system is in the return pipe near the heater, except when the heater and a portion of the piping are within a heated building, in which case the coldest water occurs at about the point of entrance to the heated room and the thermometer near the heater registers a few degrees higher than the actual lowest water temperature. The thermometer should be placed in the cold water return, not less than two or three feet from the heater, to prevent inaccuracy caused by heat conducted back along the pipe.

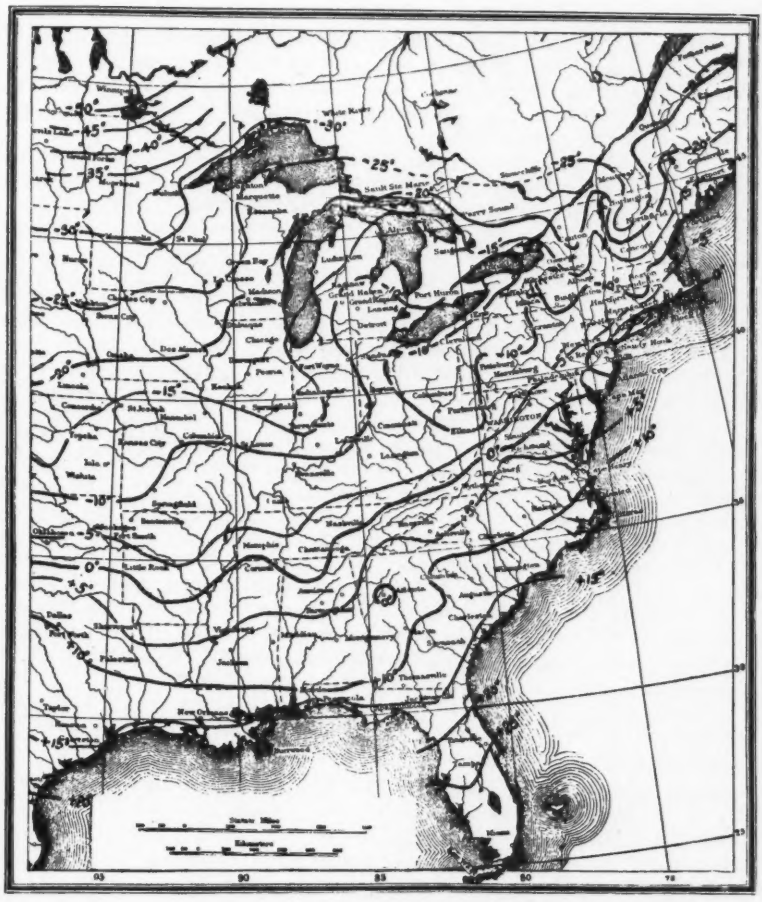


Figure II. ISOTHERMAL LINES.

Showing minimum one-day average temperatures from official records up to May, 1922. Fahrenheit degrees.

4. When steam is shut off the heater for any reason, circulation ceases, and the thermometer near the heater is no longer an index of temperatures occurring in the remainder of the piping. Steam should, therefore, at such times be turned on occasionally, and the temperature of the cold water observed after circulation has continued for several minutes to prevent the temperature of the water in the pipe from becoming dangerously low.

5. Temperature of the water in the tank discharge and cold water return at the heater should be maintained at not less than 35° F., and generally a minimum of 40° F. is advisable.

Results.

HEAT DEVELOPED. The relation between the steam pressure and the British Thermal Units delivered per hour by the heater has been determined by reducing the gallons of condensation during various periods to B.T.U.'s per hour lost by the steam and comparing with the average pressures for the same period.

The rate of condensation was found to vary with the steam pressure, and it accordingly follows that the amount of heat transmitted through the walls of the steam coil must vary similarly. Because of differences of efficiencies of various makes of heaters, a representative curve cannot consistently be given to cover the general case.

Dry steam has been assumed in making computations for total heat delivered. In view of the fact that a steam separator was installed in the supply line near the heater, and that the layout of steam mains was such as to assist in maintaining a high quality of steam, the accuracy of results based on the assumption of dry steam is commensurate with that of the rest of the test data.

While variation of the average temperature of the circulating water in the heater has an influence on the rate of condensation, such variation is comparatively small, and the effect was too slight to be observed in these tests. The amount of heat developed has accordingly been based entirely on the steam pressure which is constantly available at the heater.

HEAT LOSSES. Figure I shows the total heat loss from steel tanks in B.T.U.'s per hour per square foot of the entire exterior area of the water per Fahrenheit degree difference between the true mean temperature of the water in the tank and the atmospheric temperature for various temperature differences. The curve is an average line drawn through about 60 points, each of which represents the rate of heat loss during a time interval averaging about twenty-four hours in length.

It should be borne in mind that the average temperature of the water in the tank is several degrees higher than the cold water return. The following relations were determined in these tests.

Temp. of Cold Water Return	*Av. Temp. of Water in Steel Tank*
Fahr. Degrees	*Fahr. Degrees*
35	45
40	53
45	59
50	65
60	75
70	85

For the smaller values of temperature differences, data obtained when steam was shut off the heater was used, the heat loss being equal to the loss of the average temperature of the water multiplied by the weight of the water in the tank. For higher temperature differences, the data was obtained from periods of heating, the heat loss being the total heat developed at the heater plus or minus, respectively, the loss or gain of heat by the tank water. In the latter computation, the heat loss includes a small portion from the hot water pipe and heater, but that from the tank discharge and the cold water return is neglected.

Fig. III.

Atmospheric Temperature—Heat Loss Curves.

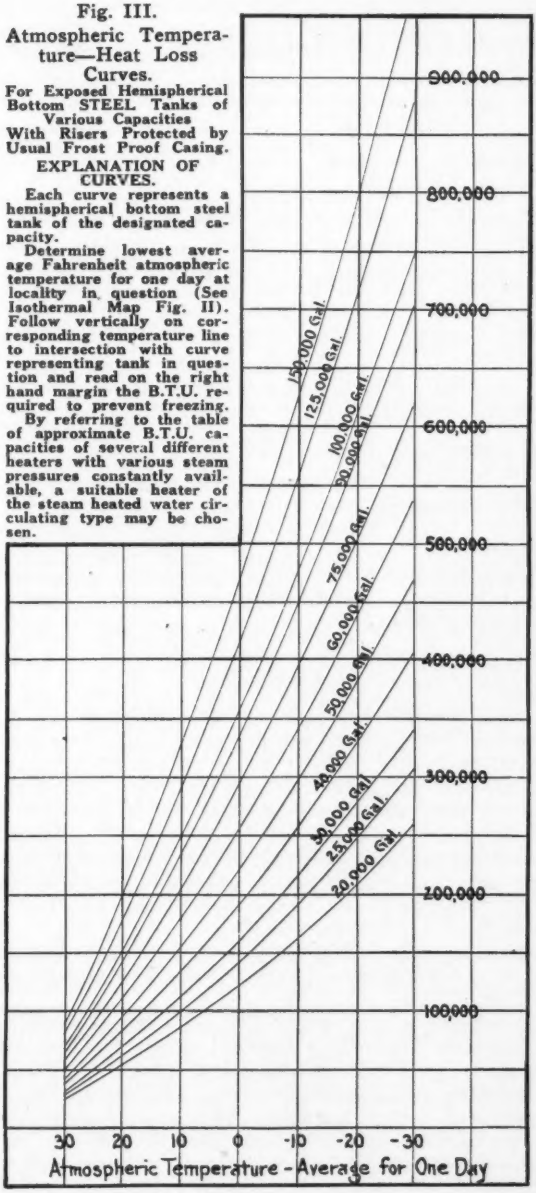
For Exposed Hemispherical Bottom STEEL Tanks of Various Capacities With Risers Protected by Usual Frost Proof Casing.

EXPLANATION OF CURVES.

Each curve represents a hemispherical bottom steel tank of the designated capacity.

Determine lowest average Fahrenheit atmospheric temperature for one day at locality in question (See Isothermal Map Fig. II). Follow vertically on corresponding temperature line to intersection with curve representing tank in question and read on the right hand margin the B.T.U. required to prevent freezing.

By referring to the table of approximate B.T.U. capacities of several different heaters with various steam pressures constantly available, a suitable heater of the steam heated water circulating type may be chosen.



Approximate Capacities of Heaters in B.T.U.'s Per Hour.

(Figures are actual input to heaters as determined by weight and temperature of condensed steam)

Heater	Size	Approximate Capacity Steam Pressure Constantly Available at Heater (See Note) 2 lbs.	5 lbs.	10 lbs.	15 lbs.	20 lbs.
General Fire Extinguisher Co.	No. 1	31000	42000	52000	59000	64000
General Fire Extinguisher Co.	No. 2	49000	66000	81000	91000	99000
Whitlock Coil Pipe Co.	No. 2	51000	69000	84000	95000	103000
*Factory Mutual Lab. Design	No. 1	59000	80000	98000	110000	119000
Whitlock Coil Pipe Co.	No. 3	67000	91000	111000	125000	136000
Pittsburgh-Des Moines Steel Co.	A	85000	115000	141000	159000	173000
R. D. Cole Mfg. Co.	B	116000	156000	192000	216000	234000
General Fire Extinguisher Co.	No. 3	124000	168000	206000	232000	252000
Whitlock Coil Pipe Co.	No. 6	139000	188000	230000	260000	282000
*Factory Mutual Lab. Design	No. 2	170000	230000	282000	317000	344000
General Fire Extinguisher Co.	No. 4	190000	256000	315000	354000	385000
Pittsburgh-Des Moines Steel Co.	B	195000	263000	323000	364000	395000
R. D. Cole Mfg. Co.	C	195000	263000	323000	364000	395000
Whitlock Coil Pipe Co.	No. 8	196000	264000	324000	365000	396000
Pittsburgh-Des Moines Steel Co.	C	366000	493000	606000	682000	740000

* Factory Mutual Laboratory Design is not manufactured for trade. The blue print design may be obtained from the Inspection Department.

EXPLANATION OF TABLE. After determining the B.T.U.'s required (Figs. II and III) for the tank and locality in question, refer to this Table in the column headed with the highest steam pressure that will be constantly available at the heater, and choose a heater of which the indicated capacity is equal to or greater than the B.T.U.'s per hour required to prevent freezing. A heater of capacity only slightly greater than the requirement will ordinarily be more economical than a larger size. When more than one heater is used, the sum of the respective ratings here given should equal or exceed the B.T.U.'s per hour necessary to prevent freezing of the tank water.

NOTE.—If the steam is less than 85% dry, the heater capacity should be reduced by the formula $H = 1.18\ T\ q$ where T is the tabular capacity, q the quality, and H the corrected capacity.

The table includes only heaters of the steam heated water circulating type with which this Department has had satisfactory experience and which have been designed with brass or copper steam coils specifically for sprinkler tank heating. The quantities shown are approximate and based on the assumption of equal efficiencies. They are not intended to represent the exact capacities of the various heaters, but may be used in connection with the heat loss curves of Figure III with satisfactory results.

Inasmuch as the layout of piping in both tests was typical of that usually encountered, no attempt has been made to differentiate between the heat lost from the tank, piping, and heater, or to compute the heat content of the metallic portions of the equipment. These local effects have no bearing on the final results which are based on total heat loss.

Next to the temperature difference, the wind velocity is the principal factor affecting heat loss. It is probable that the wind sweeps a film of warm air from the surface of the tank, thereby increasing radiation. The wind velocity during these tests was approximately twelve miles per hour and Curve I is accordingly representative of this velocity. The test observations indicate that loss of heat from steel tanks increases approximately one-tenth B.T.U. per square foot of water area per Fahrenheit degree temperature difference per hour for each mile per hour increase of wind velocity.

ATMOSPHERIC TEMPERATURES. Isothermal lines on the map, Figure II, are located in accordance with Weather Bureau records, and provide a convenient means of determining the mean temperature of the coldest day on record throughout the portions of the United States east of about 100 degrees longitude.

TOTAL HEAT LOSS FROM STEEL TANKS. The curves on Figure III have been plotted to show the number of British Thermal Units per hour lost from hemispherical bottom steel tanks of various sizes exposed to different atmospheric temperatures when the coldest water in the circulating system is at 35° F., or, in other words, the B.T.U.'s per hour required to prevent freezing at any point in the equipment under the most severe atmospheric conditions to be expected.

The curves have been drawn for average daily atmospheric temperatures varying from 30° F. to -30° F. in each case. The temperature to use for any installation is the minimum average temperature for one calendar day (see Fig. II) that has ever been officially recorded at that locality. It seems reasonable to assume that this coldest day may be repeated, but that it is improbable that an average temperature for one day will drop below this minimum.

SUITABLE SIZES OF HEATERS. The attached table has been prepared so that a heater of suitable size may be judiciously chosen. Although the table has been made to include steam pressures of 2, 5, 10, 15 and 20 lbs. per square inch at the heater, available pressures lower than about 10 lbs. per square inch should ordinarily be avoided.

Conclusions.

1. Tank heaters should be of sufficient size and have sufficient steam pressure maintained to prevent freezing on the coldest day liable to be encountered in the locality, even although the water should be near the freezing point at the beginning of the coldest period.

NOTE.—The sizes of heaters required by Figures I, II, III and the Table, are based on the actual results of these tests and are necessary in order to fill the above requirement. No allowance should be made for reserve heat in the tank, since it is always possible that the tank temperature may, by accident or otherwise, be close to the freezing point at the beginning of the coldest period.

2. Steam pressure is the principal factor affecting the amount of heat developed by the heating elements. Care should therefore be taken

that the pressure and the quality of steam used in selecting the heaters can be maintained in the coldest weather.

3. When planning and operating heating systems, careful consideration should be given to the following features:

(a) The circulating system will become partly clogged by scale, corrosion and sediment, thus restricting the free circulation upon which effective operation of the heater depends. In this connection, the hot and cold water pipes of the heater should be blown out at least once in two years, preferably at the same time as the biennial inspection of the inside of the tank.

(b) The circulating water piping should pitch throughout so as to favor circulation. Horizontal piping and pockets should be avoided.

(c) The cold water thermometer should be calibrated from time to time, and the proper correction kept in mind when operating the heater.

(d) When more than one heater is used, the units should be at the same elevation and piping symmetrically in parallel, with equal sizes and lengths of connecting piping, so that each heater will do its proportionate share of the work.

Although the calculations were made and the report prepared by the writer, the data was the joint effort of the following engineers of the Factory Mutual Laboratories: E. A. Barrier, Assistant Chief Engineer; C. W. Mowry, Director; R. E. Wilson, Engineer; H. A. Sweet, E. R. Goodrich, and C. D. Abbott, Assistant Engineers, and F. W. Frederick, Inspector.

Processes and Fire Hazards of Mattress Factories.

By S. R. Robertson,
Underwriters' Bureau of New England.
(Member N. F. P. A.)

The making of a mattress involves the preparation of the stock for stuffing, the preparation of the ticking, the filling or stuffing, and the finishing. For convenience the study of this industry is taken up under several headings as follows:

(1) Raw materials. Varieties of stock used and the characteristics and hazards of each.
(2) Manufacturing processes.
(3) Typical conditions in the industry.
(4) Summary of hazards.
(5) Record of fires classified by hazards.
(6) Recommendations for reduction of fire hazard.

Raw Materials.

Many materials are used to stuff mattresses. The following is a list of the kind of stocks most frequently used: cotton linters, cotton waste, kapok (silk floss), hair, excelsior, rattan shavings, moss, African fibre, jute waste, sisal, cocoanut fibre, straw and corn husks. Each important material will be considered separately as to its characteristics and hazards.

COTTON LINTERS. This is the hair from the cotton seed and is a by-product of the cotton seed oil mill. It is similar to cotton in that it is highly flammable and will ignite from a spark. It has very short staple and has a tendency to maintain its resiliency when compressed, differing from cotton in this characteristic. Cotton linters are often used in combination with cotton waste, first being made into wadding. It is shipped in bales similar to domestic cotton and is liable to contain foreign materials.

COTTON WASTE. Many different grades of waste are used. A good grade of comber waste with good length staple is often used with cotton linters to give body, on account of the short staple of that material. Cotton picker waste is used, at times repicked and carded. "Nappers" or waste from napping machines, flock, practically dust and sweepings, colored nappings, yarns, combings from carpet mills and cotton shoddy are also used. A low grade of cotton is used at times in the south. All these materials are extremely flammable, in handling give off considerable fly and will ignite from a spark. Some wastes are subject to spontaneous ignition, due to foreign material or oily condition. Colored yarns and waste may also be subject to spontaneous ignition from the dyes used. Stock from carpet factories shows this tendency. This waste comes mainly baled like cotton.

COTTON SHODDY is garnetted stock from cotton rags, old mattress stock, etc., and is usually shipped to mattress factories as cotton wadding.

KAPOK (silk floss) is a vegetable fibre which grows in pods on a tropical tree. The pods are like those of the common milkweed. The fibre is very light, of short staple and is slightly yellow in color. It has great buoyancy, repelling absorption of water. It is subject to internal heating when baled, and will deteriorate to a fine dust if kept a long time in the bale away from the air. In bulk this material is extremely combustible, fire spreads very rapidly in the loose materials and after the surface has burnt away rapid burrowing incandescent combustion takes place. The material gives off considerable fly when handled, and this may be ignited by an electric spark. It is shipped in bales containing about 16 cubic feet. Bales are covered with burlap or by matting.

HAIR. This is used in the highest grade mattresses. Pure hair consists of horse hair from the manes and tails. This stock is obtained mainly from South American countries where there are large numbers of wild horses. Some good grades are also received from Canada. Curled hair is received at mattress factories, in bags averaging about 50 lbs. from the hair mills, where it has previously been chemically treated, braided and baked. Cheaper grades have cattle hair mixed with horse hair and at times moss is mixed with hair at the factory. Hair burns rapidly but it will not sustain combustion in itself.

EXCELSIOR. Poplar wood is used for the manufacture of excelsior. The bark is removed and blocks about two feet long are shredded on excelsior machines. This process is not found in all mattress factories, but it is usually purchased in bales. The hazard in this material is that of a loosely packed flammable material and in many factories large piles are found in open rooms where manufacturing processes are carried on. An excelsior picker is used for loosening up baled excelsior.

RATTAN SHAVINGS. This material is obtained from rattan furniture factories and is shipped in bales, similar to excelsior, weighing about 200 lbs. Though not as combustible as excelsior, this material will burn readily with considerable smoke.

MOSS. The use of this material is not extensive. At times it is mixed with hair. It has an appearance similar to hair, being almost black and of nearly the same weight. It is the inner fibre of the Spanish moss, found in the south. This material burns readily if ignited but there is no especial hazard in its handling.

AFRICAN FIBRE. Used mainly in upholstery work, this material is found in some mattress factories. It is a grass which when dried has a resilient quality. It will burn rapidly, but alone is not a hazardous material.

JUTE WASTE. Old twine, rope, burlap bags, etc., are picked and garnetted into wadding. This material is highly combustible; the handling of it creates considerable dust, which ignites easily, and fly which hangs on piping, shafting, etc. It is also full of foreign material which causes numerous fires in its preparation. Waste from jute mills is also used.

SISAL. This is a straw like vegetable fibre obtained from Central America in bales of approximately 275 lbs. It will burn rapidly in bulk or loose, igniting readily from sparks. It is subject to spontaneous heating and decomposition when wet, but is not known to ignite from this cause. The tendency of this material to swell when wet has in a number of cases resulted in the rupture of building walls. Due allowance for this swelling must be made in piling this material in storehouses. The use of this material is limited in mattress manufacture.

COCOANUT FIBRE. The fibre of the outside husk of the cocoanut will burn rapidly. It is used more in upholstery work than in mattress making.

STRAW. This was formerly extensively used but except in the South its use has been practically discontinued. It will ignite and burn readily.

CORN HUSKS. Dried corn husks are used in a cheap grade of mattresses. This stock will burn rapidly.

Manufacturing Processes.

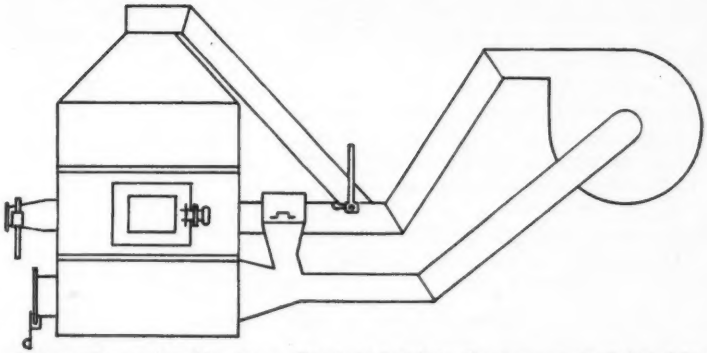
The primary process in the manufacture of mattresses is the preparation of the stock. While this is being done the tick or covering is being prepared for stuffing. Ticking is cotton twill, drills or printed duck which is first cut, then stitched together leaving an open end for filling by mattress machine, or a smaller opening when stock is to be blown into mattress. Cutting is done either by hand or by electric cutting machines.

Stitching is done by power machines. An inclined table is provided for sewing up openings after the ticking has been filled.

There are several distinct types of mattresses, namely, (a) cotton felt; (b) silk floss; (c) hair; (d) combination; (e) soft top and soft top and bottom; (f) excelsior, or similar type mattresses.

Processes of manufacture differ considerably according to the grade of goods produced.

COTTON FELT MATTRESS. Cotton linters with cotton waste of good staple for binding, with other poorer grades added in some cases for filler,



Kapok Preparing Machine. Stock is fed into the hopper at right of large cylinder and is circulated through machine by means of blower shown at the extreme right and the pipe running to top of cylinder. After 3 or 4 minutes the stock is cleaned and freed from lumps. The damper in the upper pipe is then closed and the stock is blown by means of the centre pipe to the mattress which is attached to the end of this pipe.

is run through a willower, blown through a duster, and carried to the Bramwell feed of a garnetting machine. A three unit garnet is the best type, the material being discharged on a moving platform which lays the gauze in layers. Several layers of this felt are placed and compressed in a mattress stuffing machine with movable sides and top and a metal projecting lip at one end, over which ticking, shaped and sewed, except at one end, is drawn. Felt is fed into ticking by the opposite end being moved forward by a motor driven screw.

For another type of felt mattress cotton wadding is put through a picker and is then blown through a duster and thence blown directly into the ticking. Ticking is sewed up except for a small opening which is fastened to the collar of the outlet of the blower by an iron clamp. When the desired weight of material has been blown into the mattress the blower pipe is removed and the orifice is sewed up.

Silk Floss Mattress (Kapok). The method of treating silk floss to loosen up the fibre as it is removed from the compressed bale, differs from that used in any other type of stock. Due to the lack of strength of the fibre, stock cannot be run through pickers. A special type of machine is used. The weighed stock is blown through various pipes into a circular metal chamber where the seeds drop to the bottom and the floss blows around until it is finely divided. A damper is then opened and the stock is blown directly into the mattress cover as described above.

Hair Mattress. In making the hair mattress, the hair is first passed through a hair picker. In the entire hair mattress the stock is packed evenly into mattress stuffing machine, then fed into the tick in a similar manner to the cotton felt mattress. Other types of mattresses have part hair and part felt. The hair and felt are laid in layers as in the combination mattress, the layer of hair being used in place of the felt.

Combination Mattress. This type of mattress is made by placing a layer of felt in the bottom and sides of a mattress stuffing machine and

filling the centre with cotton waste, excelsior, rattan shavings or other materials, and placing another layer of felt over this. The prepared tick is filled in the same manner as is the cotton felt mattress.

THE SOFT TOP AND SOFT TOP AND BOTTOM MATTRESS. These mattresses are made similarly to the combination mattress, except in the first case the layer of felt is placed on the top only, and in the latter on top and bottom only, the sides not being covered with felt.

The excelsior mattresses, also the mattresses in which rattan shavings, corn husks, straw and like materials are used, are made by filling stuffing machine evenly, compressing the stock and filling the prepared tick.

Practically all the stuffing materials used, except cotton felt and silk floss, are run through pickers to separate the fibres.

Typical Conditions in the Industry.

A large proportion of the mattress factories are located in city conflagration districts. Many are in old buildings of indifferent to poor general type of construction, built primarily for other types of occupancy. Unprotected floor openings, lack of protection against exposure, and poor arrangement of manufacturing hazards are features frequently found. Many of the manufacturing concerns are small. Bedstead manufacturing is associated with mattress making in a relatively small number of plants.

Due to the rather unpleasant working conditions, especially in factories manufacturing the cheaper grade mattress, a rather inferior class of help is found. These conditions result in a rather low morale and fires from smoking, careless use of matches, improper handling of stock and poor maintenance of machines are not unusual.

In some plants the locations of the dangerous processes are such that the fire resulting from these processes will cause undue loss. For example: the location of pickers or garnetting machines on upper floors, while possibly improving the efficiency of the plant in progressive processes, in event of fire makes possible considerable damage by water to valuable stock, machines, etc., on floors below.

In the New England States at present there are about 110 concerns manufacturing mattresses, though not all these produce mattresses only. About 31 of these plants have automatic sprinkler protection. A majority of them are in buildings devoted to this occupancy entirely.

Summary of Hazards.

The hazards of mattress making are primarily those of storing, handling and working a readily combustible material of a sort likely to contain dirt and foreign materials. In picking, dusting, garnetting, and similar processes to which this stock is subjected, the presence of foreign materials serves to increase the chances of sparks occurring. The dust, fly and open piles of stock which are necessarily present where these processes are carried on makes it certain that any fire will spread very rapidly. Stock blowing systems may also assist in the rapid spreading of fire.

The stock in many cases is in itself subject to spontaneous ignition due to the presence of oily material, or dyed stock liable to spontaneous heating.

Heated bearings in stock preparing machines and in stock conveyor fans, sparks from open commutator of direct current motors, unprotected electric fuses, unprotected incandescent lamps, etc., are other causes of fires.

Record of Fires.

The N. F. P. A. Fire Record files contain reports of 677 fires in this industry up to February 1922. These are summarized as follows:

COMMON CAUSES.

	No. of Fires	Per Cent of Common Causes
Lighting	18	15
Heating	3	2
Power	35	30
Boiler or Fuel	5	4
Rubbish	5	4
Chimney	3	2
Oily Material	12	11
Matches or Smoking	26	22
Lightning	1	1
Locomotive Sparks	4	3
Miscellaneous	7	6
Total	119	100

SPECIAL HAZARD CAUSES.

	No. of Fires	Per cent of Special Hazard Causes
Batting	1	.2
Dusters and Willowers	25	5
Picker	296	61
Garnet	62	13
Opener	6	1
Quilting	2	.4
Carding	17	4
Cleaning	2	.4
Feather Renovating and Repairing	8	2
Mattress Roller	1	.2
Felting	6	1
Mixing	2	.4
Mattress Filling and Cotton Condensing	4	.7
Drying	2	.4
Spreading	2	.4
Steaming	1	.2
Blower	9	2
Dust Collector	4	.7
Spontaneous Combustion	24	5
Miscellaneous	10	2
Total	484	100

	No. Fires	Per Cent
Common Causes	119	18
Special Hazard Causes	484	71
Exposure	6	1
Incendiary	5	1
Unknown	63	9
Total	677	100

ROOM IN WHICH FIRE OCCURRED.

	Common Hazards		Special Hazards		Unknown		Total	
	No. of Fires	Per Cent	No. of Fires	Per Cent	No. of Fires	Per Cent	No. of Fires	Per Cent
Repairing					1	2	1	.1
Storage and non-manufacturing	19	16	22	4.5	10	15	51	7.7
Opening			4	.7			4	.6
Motor	4	3					4	.6
Boiler	8	7	2	.4	1	2	11	1.6
Felting	1	1	3	.7			4	.6
Duster and Willower	1	1	10	2.			11	1.6
Picker	14	12	249	52.	6	10	269	40.7
Garnet	4	3	54	11.			58	8.7
Drying			1	.2			1	.1
Carding			23	4.8			23	3.4
Dust			10	2.			10	1.5
Gauze			7	1.4			7	1.
Stuffing	1	1	1	.2			2	.3
Feather Renovating	2	2	10	2.	2	3	14	2.1
Floss Department			4	.8	2	3	6	.9
Mattress Quilt, Making and Filling	6	5	7	1.4	5	8	18	2.7
Cleaning	1	1	1	.2			2	.3
Shoddy			1	.2			1	.1
Batting			2	.4			2	.3
Steaming			2	.4			2	.3
Basement	4	3			2	3	6	.9
Outside	3	2					3	.4
Excelsior Dept.					1	2	1	.1
Upholstery Dept.					1	2	1	.1
Finishing					2	3	2	.3
Unknown	51	43	71	14.7	30	47	152	23.
Total	119		484		63		666	

This record of fires was prepared for this article by the Department of Fire Record. This supersedes the similar Fire Record published in QUARTERLY Vol. 4. No. 4, April, 1911, page 533.—Ed.

EFFECT OF SPRINKLERS.

	No. of Fires	Per Cent
Extinguished or practically extinguished...	337	72
Held fire in check	124	26.3
Failures	7	1.7
Total operating	468	
None operating or not a factor	100	
Total	568	

General Suggestions for Reduction of Hazard.

AUTOMATIC SPRINKLERS. The nature of the hazard of mattress making is such that protection of the factory by automatic sprinklers is almost a necessity if the manufacturing is to proceed without serious interruption. The provision of such protection for mattress factories in city districts, and in buildings having other tenants should be required by law in order to safeguard surrounding property and the lives of workers. That sprinklers afford effective protection is amply shown by the actual fire record. Of 468 fires recorded, 72% were entirely extinguished, and 26.3% were held in check satisfactorily by the sprinklers, while only 7, or 1.7%, were not satisfactorily controlled. In several of these cases in which sprinkler action was unsatisfactory the sprinklers were shut off at the time of the fire, while in others the water supply was deficient or temporarily impaired.

PREPARATION OF THE BUILDING. Whether or not automatic sprinklers are provided, it is important that stairways, elevators, beltways, and other vertical openings through the building be effectively cut off or shut off by tight enclosures, in order that fire will not spread rapidly from floor to floor. The protection of vertical openings is recognized as a measure of vital importance in a building of any class and the standard methods of providing such protection need not be set forth here. The severe conditions obtaining in mattress factories dictate that the measures of protection provided be exceptionally thorough.

ISOLATION OF HAZARDS. It is patently unwise to expose considerable values in goods to severe hazards. To prevent such exposure in a mattress factory it is necessary to isolate pickers, cards, garnetting machines, and dusters. These machines should be in areas so separated from others that the damage from fire, smoke and water may be readily and normally confined to the immediate vicinity of the machine. By reducing the area to which fire will quickly extend, it is possible to more effectively use fire pails, chemicals, and small hose in extinguishing the fire. In sprinklered plants the water available for the automatic sprinkler system is conserved and used only at the seat of actual fire, for without enclosures of this sort, sprinklers at some distance from the fire may be operated to no advantage.

Where possible, pickers and garnetting machines should be located in a detached or cut off building, following the well established good practice of cotton mills in this respect. Where these machines are of necessity located in the building housing the remainder of the plant, they should be in rooms shut off from other areas by tight partitions of fire-resistive construction, with automatic fire doors at all necessary openings,

such rooms to be so located that exit from them is easy and safe. Care should be taken to insure that fire in them will not endanger the main exits or fire escapes of the building by smoke or otherwise. If such rooms are located on any floor above the lowest, the floors should be watertight and fitted with scuppers or floor drains of ample capacity, so that water used in the extinguishment of fire will not cause damage on floors below. Dusters, willows, nappers, hair and excelsior pickers, and similar machines, should be in rooms shut off from other areas.

Gauze rooms or flock rooms, to which stock is blown from pickers or similar machines, should be of small size and their interior walls, floors, and ceilings should be amply fire resistive. The necessary vents from such rooms should be amply screened.

Dust rooms to which pickers discharge should be prepared in the same manner as the gauze room, but especial care should be taken to provide adequate vent or dust chimney. Dust carried through the dust room may collect on the exterior of the building and fires in lint so deposited have in a number of instances resulted in considerable losses. The dust flue should have four square feet of area for each connected picker fan in order to allow proper deposition of the dust in the dust room. Where cyclone separators are used, their size should be ample and they should be so located as to be easy of access in case of fire, and for cleaning and repair. Pickers and garnets should be properly hooded to insure that the dust is carried away from the machine.

Power. Where line shafting is employed, bearings should be made readily accessible and precautions taken to insure that they are kept clean and well lubricated. Static electric discharges from belts should be avoided by proper grounding of shafts, especially in dusty rooms.

Where motor drive is employed, alternating current is preferable. Direct current motors if used should be of the totally enclosed self-ventilating type, or be located in enclosures where dust will not penetrate. Preferably no motor of any sort should be located in the picker room or other dusty enclosure. The drive for such rooms should be from outside by belt or shaft. Switches should be of the enclosed type, and so located that they shall at all times be clean. Switches of any sort are undesirable inside picker rooms, and if possible should be located outside. Fuses should be carefully located and enclosed in standard metal cabinets. All power wiring is best installed in conduit.

Lighting. In picker rooms and similar dusty areas, light wiring should be in conduit, and lamps should be of the double enclosed type. Elsewhere the lighting equipment should be in accordance with the standard, but portable lights should be avoided. Guards should be provided for lamps exposed to danger of breakage. No open flame light such as gas or oil lights should be permitted.

Heat. All fire heated apparatus should be excluded from the factory area. Boiler or heated rooms should be cut off by walls or partitions of fire-resistive material.

Storage of Stock. The storage of bales of combustible fibre stock may present the danger of severe and stubborn fire. The storage area should be devoted to this purpose only. Single areas for stock storage should not exceed 5000 square feet, bales should be piled one on end

only, and good aisle spaces should be maintained.

OPERATION. To a large extent safety from fire depends on the degree of care and cleanliness which is maintained in the operation of the plant. The amount of stock and broken bales exposed in work rooms should at all times be kept at a practical minimum and should not exceed the supply for one day's operation. Smoking should of course be forbidden under penalty of discharge.

MINOR PROTECTION. If for any reason automatic sprinklers may not be provided throughout, they should at least be provided in picker rooms, the water supply being obtained from the service pipes if necessary.

In addition to the provision of the standard supply of fire pails and chemical extinguishers, there should be at least three 2½ gallon chemical extinguishers, and small hose for each picker room. With an ample supply of hand extinguishing devices at hand, intelligent workmen can usually extinguish picker fires with trivial loss.

Baltimore Terminal Fire.

Report by Railroad Insurance Association

(Member N. F. P. A.)

During an electrical storm on the evening of July 2, 1922, lightning struck the roof of an elevator at the Baltimore and Ohio Railroad Terminal at Locust Point, Baltimore, Md., and the resulting fire destroyed two elevators and two piers with a loss of well over a million dollars.

Description of Property.

The two grain elevators, "B" and "C," were wood frame, with wood bins, Elevator "C" having the bins encased with brick walls and operating house metal covered. Capacity of "C" was about 1,300,000 bushels and of "B" about 1,200,000 bushels. Both were about half filled at the time of the fire. Pier No. 2 was an export merchandise pier, frame, metal covered. Pier No. 5 consisted of a long open pier with a 2½-story brick warehouse at bulkhead end about 270 x 80 ft., wood roof and floor construction. All roofs were composition covered. Pier 2 was east of Elevator "C" across a 150 ft. slip. Elevator "C" was 250 ft. east of Elevator "B" and Pier 5 was 125 ft. to 200 ft. west of Elevator "B." There were two tracks on Pier 2 in pit with capacity of about 60 cars. Tracks also entered elevators, but contained only one car at time of fire. Classification and terminal yard is about 75 ft. from bulkhead line in front of all piers and elevators, with total capacity of about 2250 cars. No steamers were tied up at piers or elevators at time of fire. Some car floats and barges were tied up, but were removed except for one destroyed and two damaged.

Elevator "B" and brick warehouse on Pier 5 at the height of the fire. Both of these structures were destroyed.

Protection.

An excellent system of large size mains, with approved hydrants well distributed, fed by pumps with total capacity of 4750 gallons per minute, furnished outside protection for the properties at this terminal. Hose supplies were ample, with sufficient number of nozzles, etc. Fire brigade well organized and slept on property at night and were on duty during daytime, Sundays and holidays. There was a competent fire marshal and good city fire department protection with engine house about four blocks distant. City fire boats were about five minutes' run, also railroad tugs with pumps and monitor nozzles were around the terminal at all times. There were standpipes with connections equipped with hose throughout all buildings, as well as water barrels and extinguishers. All protection was very well maintained. A. D. T. combined watchman's and fire alarm boxes were installed throughout the properties. This protection, including fire escapes on elevators, was installed following recommendations of the underwriters.

Weather Conditions.

The maximum velocity of wind during the fire is given by the weather bureau as 30 miles per hour. The direction of wind was east and southeast from 5.06 P. M. to 6.38 P. M., and then from south until 7.25 P. M., and north to northwest between 7.25 to 10.30 P. M., and northeast steadily thereafter. Temperature 83 degrees at 5 P. M., 69 degrees at 5.30 and 6.00 P. M., 85 degrees at 7.00 P. M., and 75 degrees at 8 P. M.

Story of the Fire.

Lightning hit Elevator "B" at about 5.30 P. M. A watchman was in the top of this elevator but he escaped injury and turned in a fire alarm immediately from an A. D. T. box at hand. The private fire brigade responded immediately, taking hose into the building. However, the fire spread so rapidly that the brigade could do nothing with the standpipe and hose in the building and were forced to use the spiral slide fire escapes to get out of the building. The city fire department responded quickly to the first alarm and a "third" alarm was sounded immediately on their arrival, quickly followed by a general alarm, bringing out all the companies in the city (51 engines), more than half of which were held at the fire. All five of the city fire boats and several tugs of various railroads, equipped with fire apparatus, responded. The fire spread rapidly and soon set fire to the warehouse on Pier 5 despite closed iron shutters, Pier 5 being west of Elevator "B" and wind being from the east. At that time streams were being directed on Elevator "C" from outside and also over the side of buildings from inside standpipes. Fire boats were in the slip between the two elevators. About 7.30 to 8.00 P. M. the wind suddenly shifted, due to another storm, and blew from north and west, and toward Elevator "C," setting that building on fire and causing fire boats to abandon their positions. The wind continuing from the north and west, embers and heat were carried to Pier 2, igniting that structure despite efforts to save it. Then wind again shifted to northeast, enabling firemen to save Pier 1 and Annex Pier 2.

Twenty-eight standard hose streams were used on the plant water system, with pumps maintaining from 100 to 130 pounds. There was no break in the water lines, nothing went wrong with the pumps, the fire alarm system functioned, the plant fire brigade responded in minimum time, and altogether it would appear that the fire was fought as efficiently as possible, with all the protection, which was excellent, working properly.

Conclusions.

The impossibility of combating fire in old frame elevators, even with good protection, is again illustrated. The immensity of these structures causes such large amount and degree of fire, that buildings hundreds of feet away are threatened and often destroyed. In this case, an excellent protection system for private plant and a highly rated city department were impotent to stop fire from communicating to structures 300 ft. distant. Proper planning and construction of modern structures for such hazardous and valuable occupancies will prevent such conflagrations.

The fire escapes on the elevators undoubtedly prevented loss of life.

The efficiency of the fire protection system at this terminal was proved, but was of little avail against the factors of changing wind and the elements, except as to preventing further possible loss.

Saw Mills; Fire Record.

A fire record of saw mills was published in the *Special Hazard Bulletin* for October, 1906, and included 85 fires. The present classification brings the record up to date. 814 fires are recorded. The susceptibility of this class of occupancy to serious and sweeping fires is well known and is borne out by the figures. More than a quarter of the fires recorded (27.4%) show a total loss of the buildings and property. In only 21.2 per cent of the fires was the loss less than one thousand dollars. These figures indicate the importance of fire prevention measures in saw mills. A fire once started is hard to check. An unusually large number of the fires are reported as of unknown cause, probably due to the fact that the rapid spread of these fires destroyed evidence of their origin. The known causes are evenly divided between common and special hazards. Sparks from boilers were responsible for the largest number of fires. A spark is all that is necessary to start a blaze in the accumulation of dry tinder prevalent in saw mills. Power fires, particularly overheated bearings and hot boxes, are common to this class. Fire often originates in the dry kiln; the exact cause being difficult to determine. Incendiarism, sparks from locomotives, and rubbish are other common causes of fire.

Less than a quarter of the saw mills in this record were sprinklered. It should be noted that 96.4 per cent of the total loss fires were in unsprinklered mills, while 71.2 per cent of the small loss fires were in sprinklered mills. The sprinkler record again indicates the severity of saw mill fires. An average of 37 heads opened per fire is much higher than for most other occupancies. The number of sprinkler failures is also high.

Some Typical Fires in Saw Mills.

Unknown Cause.

S-28427. The main building was a two-story frame strucure adjoining a brick power house. A fireman in the power house noticed smoke and flames coming through the main belt way from the saw mill to the engine room. The fire spread with great rapidity through the frame mill and communicated to the power house through unprotected openings. So rapid was the spread that in about fifteen minutes the power house was destroyed. A large smoke stack, becoming red hot, collapsed and fell against a large frame building which was destroyed. In one hour the fire travelled from its origin in the mill to the cooper shop located about 900 feet away, entirely consuming all buildings in its path. The sprinklers were of no value as the supply pumps in the power house were destroyed early in the fire.

This fire illustrates the need of adequate water supplies for sprinklers and protection of buildings against exposure.

Saw Mills—Fire Record.

Total Number of Fires Reported 814.

Classification of Causes.

Common Causes.

	No. of Fires	Per Cent of Common Causes	Per Cent of Total Known Causes
Power (largely hot bearings)	106	39.7	20.7
Incendiary	35	13.1	6.8
Sparks from Locomotive	20	7.5	3.9
Exposure	19	7.2	3.7
Rubbish	18	6.8	3.5
Matches—Smoking	12	4.5	2.4
Lightning	12	4.5	2.4
Open Lights	11	4.1	2.2
Heating	10	3.7	2.0
Lighting	6	2.2	1.2
Electric Wiring	4	1.5	.7
Spontaneous Ignition	4	1.5	.7
Miscellaneous Common Causes	10	3.7	2.0
Total	267	100.0	

Special Hazard Causes.

	No. of Fires	Per Cent of Special Causes	Per Cent of Total Known Causes
Sparks from Boiler	152	62.3	29.7
Dry Kiln (exact cause unknown)	38	15.6	7.4
Sparks from Refuse Burner	25	10.2	4.9
Sparks from Slab Burner	10	4.1	2.0
Defective Insulation of Boiler	7	2.9	1.4
Dust Explosion	2	.8	.4
Miscellaneous	10	4.1	2.0
Total	244	100.0	

		Per Cent of Total
Common Causes	267	32.8
Special Hazard Causes	244	30.0
Total Known Causes	511	62.8
Unknown Cause	303	37.2
Total	814	100.0

Analysis of Loss.

	Loss Less $1000	Per Cent	Loss More $1000	Per Cent	Total Loss	Per Cent	No Data	Per Cent	Total	Per Cent
Sprinklered	123	71.2	59	15.7	8	3.6	5	11.9	195	24
Unsprinklered	50	28.8	317	84.3	215	96.4	37	88.1	619	76
Total Fires	173	100	376	100	223	100	42	100	814	100

	No. of Fires	Per Cent
Loss Less $1000	173	21.2
Loss More $1000	376	46.2
Total Loss	223	27.4
No Data	42	5.2
Total	814	100.0

Sprinkler Fire Record.

	No. of Fires	Per Cent
Extinguished Fire	79	44.6
Held Fire in Check	57	32.2
Unsatisfactory	41	23.2
Total	177	100.0

There were eighteen fires in which no sprinklers opened.

Comparison of Wet and Dry Systems.

	Ext. Fire	Held in Check	Unsatisfactory	Total
Wet System	15	14	9	38
Dry System	64	43	32	139
Total	79	57	41	177

Number of Sprinklers Opened. (Average 37.)

No. of Sprinklers Operating	No. of Fires	Per Cent
1	25	18.4
2	18	13.2
3	7	5.1
4	12	8.8
5	6	4.4
6-9 inclusive	10	7.4
10-25 inclusive	23	16.9
26-50 inclusive	14	10.3
51-100 inclusive	6	4.4
101-200 inclusive	2	1.5
201-300 inclusive	4	3.0
Over 300	9	6.6
	136	100.0
All Heads Opened (No Data as to number)	15	
No Heads Opened	18	
No Data	8	
Total	177	

Miscellaneous Statistics.

Day or Night Fires. (Day Fires 6 A. M. to 6 P. M.)

	No. of Fires	Per Cent
Day Fires	329	40.5
Night Fires	426	52.5
No Data	59	7.0
Total	814	100.0

How Discovered.

	No. of Fires	Per Cent
Employee	316	38.9
Watchman	266	32.6
Outsider	140	17.2
Sprinkler Alarm	28	3.4
Watchman and Sprinkler Alarm	16	2.0
Thermostat	1	.1
No Data	47	5.8
Total	814	100.0

Room in Which Fire Occurred.

	No. of Fires	Per Cent
Main Plant	169	20.8
Boiler Room	137	16.6
Dry Kiln	74	9.1
Engine Room	42	5.2
Lumber Yard	33	4.1
Shavings Vault	32	3.9
Basement	30	3.7
Storage Shed	23	2.8
Roof	22	2.7
File Room	16	2.0
Miscellaneous	16	2.0
No Data	220	27.1
Total	814	100.0

Power.

H-15871. The mill was in full operation when fire started due to an overheated journal. The operator of the rotary saw noticed smoke coming up under the saw bed. He shut off the power and on reaching the basement found fire burning around the steam engine. This engine was enclosed by wooden partitions to keep out sawdust. On opening the door of this enclosure the flames burst out and spread through the basement so fast that men carrying hose from a standpipe had to drop it and run. A strong wind spread the fire and a total loss resulted. Embers set fire to lumber piles in the yard and to buildings three hundred feet distant. Thirty-four buildings were destroyed. There were no fire fighting facilities available.

Sparks from Boiler.

H-8084. The boiler furnace was fitted to burn either gas or refuse. It was burning refuse and a small leak in the gas pipe caused a slight explosion. The puff blew some sparks out of the furnace into the open door of the shavings vault. A total loss resulted.

Exposure.

H-14306. The mill was closed at the time of the fire and considerable refuse had been allowed to collect underneath the building. Sparks from a donkey engine on neighboring premises set fire to this refuse. The watchman had left the building to go home for dinner and the mill was destroyed.

Open Light.

H-13665. The building was a two-story frame structure with a brick boiler house and adjoining storehouses of frame. Fire was discovered about 3 A. M. by an outsider. The watchman, carrying a lantern, had made his rounds and returned to the office. He either fainted or had a shock and fell breaking the lantern. He was burned to death and most of the main building was destroyed.

Sparks from Refuse Burner.

S-23748. Fire originated when sparks from a refuse burner were carried by a strong wind into the building through a louvre in the roof. The fire spread rapidly and entered the brick boiler house through the belt hole and doors, destroying the contents. The fire carried toward lumber dry kilns by the wind totally destroyed intervening storage platforms. The dry kilns were protected by sprinklers and the fire was checked after the doors had burned off.

Dust Explosion.

S-30472. This mill was a two-story structure, metal clad on open wood frame. The mill was very dusty and dust was blown off beams by steam on Sunday. The explosion occurred on Saturday night when there was a considerable accumulation of cedar dust throughout the plant. Fire flashed through the basement and first floor. Part of the sprinkler system was inoperative on account of plugged piping and the fire gained sufficient headway to do large damage.

Interesting Fires.

Brief Summary of Some Fires Recently Reported to the Department of Fire Record.

Rubbish.

H-18813. Fire occurred in a small room under the stairs at the front entrance of a two-story brick and frame building. The first floor was used for a motion picture theatre, seating capacity about four hundred. The second floor was unoccupied. The joists, floors, stairs and front wall were of wood, and between the ceiling of the first floor and flooring of the second floor was a large hollow space which furnished a ready path for rapid spread of fire throughout the building. In a room under the stairs, measuring 6 x 9 feet, were located the main electric cabinet, an electric motor, starting rheostats, portable electric lamp wired with signal wire, and other electric switches; also the steel safe and office files. Other items found in the room were paper, rags, kerosene, lanterns, paint cans, paint brushes, turpentine, cleanser containing gasoline, etc. Fire starting in this rubbish in a short time involved the exits and the orderly egress of two hundred or more imperilled persons through the burning exits of this building is a remarkable case of self control. The slightest panic would have very likely resulted in considerable loss of life. The fire was extinguished by the fire department.

Radio.

H-18774. Fire occurred when lightning entered a room which contained a radio set. The radio equipment was installed in accordance with the rules on wireless receiving apparatus; a defective lightning arrester is believed to have been responsible for the trouble. Two separate fires took place.

One originated in the amplifier set on a wooden table due to current jumping to a sheet of aluminum used under the instruments as a common ground. The arc was of sufficient intensity to melt several holes in this metal and the molten particles ignited adjacent inflammable material.

The other fire originated between the lead-in wire to the instruments and the ground wire from the lightning arrester to a water pipe, at a point where they extend side by side under the window ledge. The rubber insulation on both wires was burned off for about two feet; the window ledge burned to a depth of ¼ inch; lace curtains and window shades were also destroyed. This fire was due to current jumping from lead-in wire to ground wire, the resultant arc being of sufficient intensity to ignite the rubber insulation.

Flammable Floor Covering.

H-18773. Painters were at work in the basement of a new fire-resistive office building. A patented plastic floor compound was being laid down. This material was mixed with gasoline to a consistency that allowed easy spreading on the floor. The careless act of some workman in lighting a match ignited the gasoline fumes from this plastic floor compound, the resulting blaze spreading immediately to newly varnished partitions creating a hot fire that lasted about twenty minutes. The burning of these materials created a very concentrated gas which resulted in the loss of life of four workmen who were trapped in a vault.

Cigar Lighter.

A tobacconist started to replenish his cigar lighter with gasoline. A spark from the machine ignited the liquid, which spread over his show cases and stock. His clothes caught fire and before the flames could be extinguished his arms and hands were badly burned.

Sparklers.

A fifteen-year-old girl was burned to death when her dress caught fire from one of the sparklers in a five-pointed star she was carrying in a play given by school children. When the school janitor attempted to smother the flames, she wrested herself from his grasp and ran out into the hall where 300 children were huddled in panic. The flames were extinguished by the school nurse, who wrapped a linen duster around the girl. She died a few days later.

Gas Balloon.

A ten-year-old girl was badly burned about the face and hands when a toy balloon exploded after being ignited by a lighted match. The child was sitting on the veranda when the balloon came in contact with a match in the hands of a friend. There was a deafening explosion and the hands and face of the little girl turned copper colored.

Gasoline.

Upwards of three thousand dollars loss was caused to a garage when an employee who was busy vulcanizing a tire thought that a little blaze of spilled gasoline on the floor would burn itself out. The flames found some more gasoline and flammable material on the floor and the whole place was ablaze before he knew what was going on. The fire reached the gasoline tank of the vulcanizer, which spouted flames over the desks, typewriters, and piles of tires in the garage office. All were a total loss.